

**MOKELUMNE RIVER
CHINOOK SALMON AND STEELHEAD
MONITORING PROGRAM
1997-1998**

Administered by:

**East Bay Municipal Utility District
Fisheries and Wildlife Division
500 San Pablo Dam Road
Orinda, California 94563**

A Technical Report on

**Evaluation of the Downstream Migration of
Juvenile Chinook Salmon and Steelhead in the Lower
Mokelumne River and the Sacramento-San Joaquin Delta
(December 1997 through July 1998)**

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EXECUTIVE SUMMARY

The objective of the East Bay Municipal Utility District's Mokelumne River Chinook Salmon and Steelhead Monitoring Program (monitoring program) is collection of information on the ecology and management of anadromous salmonids and other fishes inhabiting the lower Mokelumne River. This report provides summary data for fishes captured, assessments of the downstream migration of juvenile fall-run chinook salmon and steelhead, and results of mark-recapture experiments of hatchery-reared juvenile salmon migrating through the Sacramento-San Joaquin Delta during 1998.

Two rotary screw traps were fished for 225 days between December 15, 1997 and August 2, 1998 at Woodbridge Dam. Juvenile chinook salmon were the most abundant species captured. Prickly sculpins and juvenile Pacific lampreys were the next most abundant native fishes. A number of sunfishes (family: Centrarchidae) and juvenile common carp were the most abundant introduced fish species' trapped. Young-of-the-year fall-run chinook salmon emigration pattern was bimodal with distinct peaks for fry in late-January/early-February and for smolts in May. Fry numbers diminished by early March. Most fry passing Woodbridge Dam were recently "buttoned-up" (with fully absorbed yolk-sac). Although trapping was started on different dates since 1990, abundance of naturally produced chinook salmon (fry and smolts) in 1998 was the highest so far observed, estimated at 1,848,539 (95% C.I. : 1,543,355 - 2,592,219). Approximately 70% emigrated as fry and 30% as fingerling smolts.

Of 445 steelhead smolts (age 1+) captured from December through July 1998, 87% were adipose fin clipped. Over 95% of smolt-sized steelhead were captured within one month of the MRFI steelhead smolt release. Fifty-one YOY steelhead were captured from January to August, mostly from mid-April through July 1998. No abundance estimate for steelhead was possible. Seven juvenile kokanee salmon, presumed to have passed by Pardee and Camanche Dams, were captured from January to August 1998.

River flows at Woodbridge Dam ranged from about 500 to 1,000 cfs from December 1997 through January 1998. Flood control releases increased flows to a peak of about 3,500 cfs in mid-February followed by a gradual decline to between 1,400 to 1,700 cfs by the end of March. Flows remained at these levels until late June when flows increased to between 2,000 to 3,200 cfs through July. Daily water temperatures at Woodbridge Dam through the rearing and emigration season varied from 49°F early in the year to 62°F in June and July. No distinct associations were observed between the abundance of juvenile salmon emigrants and the range of river flows and water temperatures experienced in 1998. Peak catches of fry were associated with storms and increased turbidity. Fry abundance was coincident with the expected timing of their emergence from the redds peaking in late-January/early-February. Fingerling-sized salmon smolts were observed in the traps after mid-March as in past years. Smolts were abundant from April through June, peaking during the full moon in May. During the peak migration period, salmon smolts migrated mostly during the night and morning hours with notable peaks of

abundance near dawn, through the morning hours, and again near dusk. Estimated migration abundances during daylight hours were generally low throughout the season. Little flow variation occurred during the smolt emigration and no specific conditions appeared to be associated with the patterns of migration.

Two duplicated groups of approximately 103,000 hatchery young-of-year (YOY) chinook salmon were coded-wire tagged and released in the Delta to evaluate migration survival during the peak of the migration and coincident with a managed Delta pulse flow from April 15 to May 15, 1998. A *test* group of marked fish was released in the Mokelumne River near its confluence with the Delta and a *control* group was released 7 days later in the San Joaquin River below the Mokelumne River confluence near Jersey Point. The estimate of relative survival was 35.5% (95% C.I. = 26.8% to 44.2%) for the test group compared to the control group. This was the highest survival for this evaluation since 1996. Survival of Mokelumne River smolts migrating through the Delta was higher but comparable to that for Merced River smolts emigrating from the San Joaquin River which averaged 31%.

From March 1 to August 2, 1998, 55,632 naturally produced chinook salmon were captured, coded-wire tagged, and released at Woodbridge Dam. Approximately 8,500 of these were tagged and released as fry or parr. Thirteen fish tagged as fry and 20 tagged as smolts were recaptured by the USFWS trawl at Chipps Island from April to June 1998.

I. OBJECTIVES

This report addresses two objectives of East Bay Municipal Utility District's (EBMUD) 1997-98 Mokelumne River Chinook Salmon (*Oncorhynchus tshawytscha*) and Steelhead (*O. mykiss*) Monitoring Program:

- Monitor abundance and emigration timing of juvenile anadromous salmonids within the Mokelumne River.
- Conduct mark-recapture experiments to determine survival of hatchery-reared chinook salmon smolts migrating through the Mokelumne channels of the Sacramento-San Joaquin Delta (Delta).

These objectives are integral to the ongoing collection of information on the ecology and management of anadromous salmonids in the lower Mokelumne River (Figure 1). Specific tasks performed in support of these program objectives during 1997-98 were:

- Monitor the daily abundance and downstream migration patterns of naturally produced juvenile anadromous salmonids passing the Woodbridge Irrigation District Dam (WIDD).
- Monitor size and condition of emigrating juvenile anadromous salmonids and determine the proportions of juvenile salmon emigrating as fry and as smolt-sized salmon.
- Evaluate juvenile anadromous salmonid emigration patterns related to environmental factors (i.e., stream flow, water temperature, lunar phase, precipitation, water turbidity, and time of day).
- Coded-wire tag (CWT) naturally produced chinook salmon smolts for ongoing assessments of population-level responses to management actions and fishery recruitment of the Mokelumne River fall-run chinook salmon stock.
- Assess the relative survival of CWT Mokelumne River Fish Installation (MRFI)-reared salmon smolts migrating through the Delta under various hydrologic and water management conditions.
- Evaluate the results of the preceding tasks in the context of ongoing resource monitoring activities and management actions on the lower Mokelumne River.

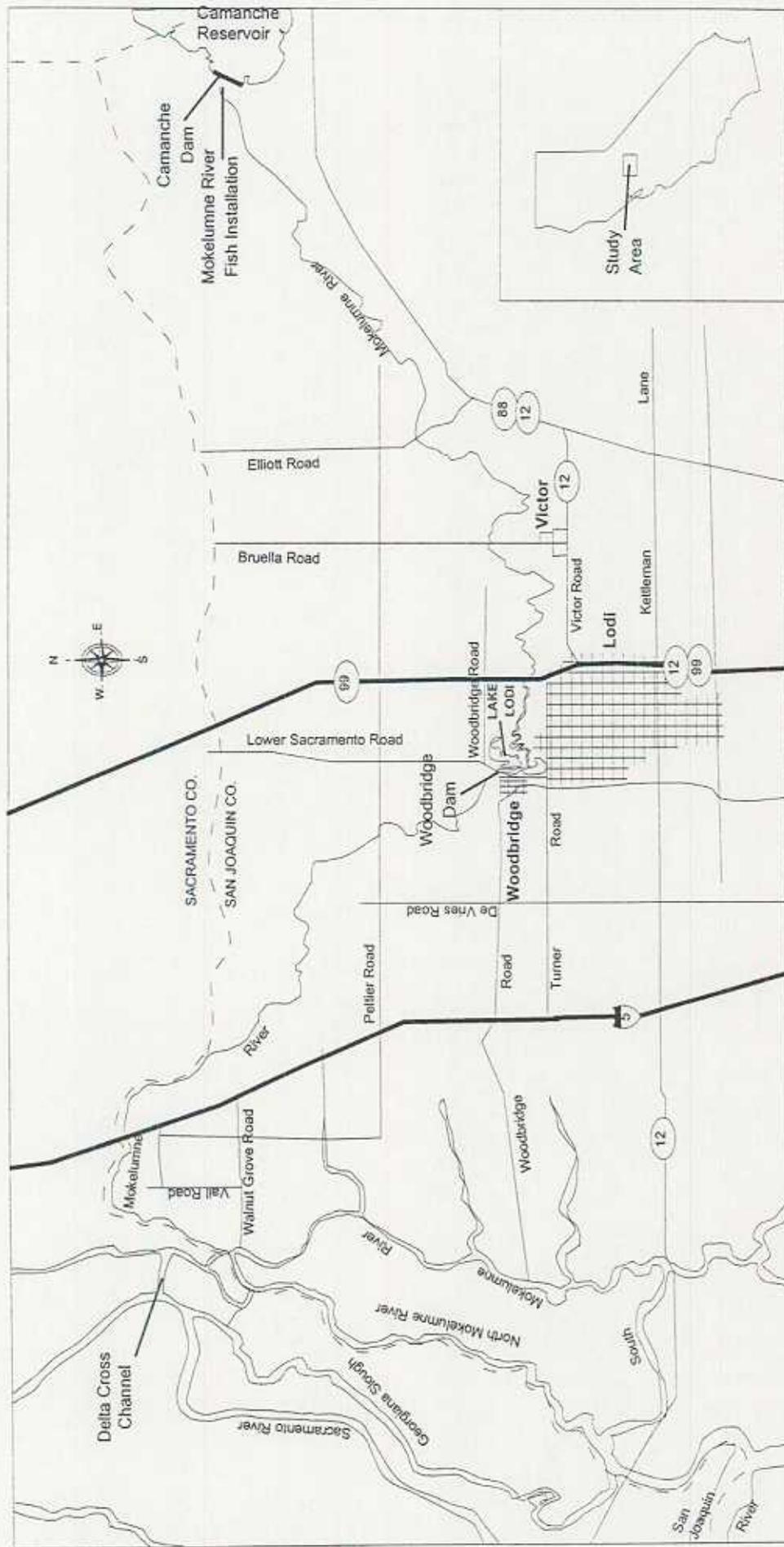


Figure 1. The Mokelumne River from Camanche Dam to its confluence with the San Joaquin River.

II. METHODS

2.1 Downstream Migrant Trapping at Woodbridge Dam

2.1.1 Rotary Screw Fish Traps

Woodbridge Dam has been used as a trapping site for downstream migrant salmonids since inception of EBMUD's Mokelumne River Fishery Monitoring Program in 1990. During December 15, 1997 until August 2, 1998, two 2.4-m-diameter rotary screw fish traps were fished in tandem immediately downstream from Woodbridge Dam (Figure 2). The two traps were rigidly connected side by side. The trap suspension and operation system at Woodbridge Dam was similar to that described by Vogel and Marine (1994). When feasible, traps were positioned where the trapping cone rotation could be maintained at a minimum 4 revolutions per minute.

2.1.2 Fish Handling and Measurements

The fish traps were tended at least twice daily. This was generally done early in the morning and late in the afternoon. During periods of high riverine debris loads and/or large catches of fish, the traps were attended more frequently throughout the day. Fish captured were transferred from the trap live boxes with dip nets to 20-liter (L) buckets filled with fresh river water. To facilitate longer holding times (>15 minutes), fish were transferred to a 380-L PVC flow-through holding tank with a flow rate of about 35-L per minute. Fish were sedated in aerated river water with 30 to 50 mg/L of tricaine methane sulfonate¹ buffered *w/w* with sodium bicarbonate. This formulation was selected for rapid and short-term induction of a moderate level of sedation for most of the species captured (Summerfelt and Smith 1990). All fish were identified to species (when possible) and enumerated.

Up to 30 of each salmonid species captured in each trap during each trapping period were randomly sampled for measurements of total length (TL) and fork length (FL) in millimeters (mm) and weighed in grams (g) on an Ohaus CT1200 portable balance. Weighing was done in tared beakers of fresh water set on the balance pan. Individual sedated fish were gently blotted on a moist sponge to remove excess water before weighing to ensure measurement of true wet weight. These measurements were recorded along with observations of external disease and injury. All adipose fin-clipped salmon (indicating CWT implants) and salmon otherwise marked that were observed among the fish counted or measured were recorded. After counting and measuring, fish were gently placed in a 20-L bucket of fresh river water or live car placed in a flow-through tank with pumped-in river water to recover from sedation before being released downstream of the traps. Total processing time for individual fish from sedation and measurement to recovery and release was generally 15 to 30 minutes. Fish were distributed among several buckets or live cars to avoid overcrowding and depletion of dissolved oxygen

¹"Finquel" formulation, sold by Argent Chemical Laboratories, Redmond, Washington.

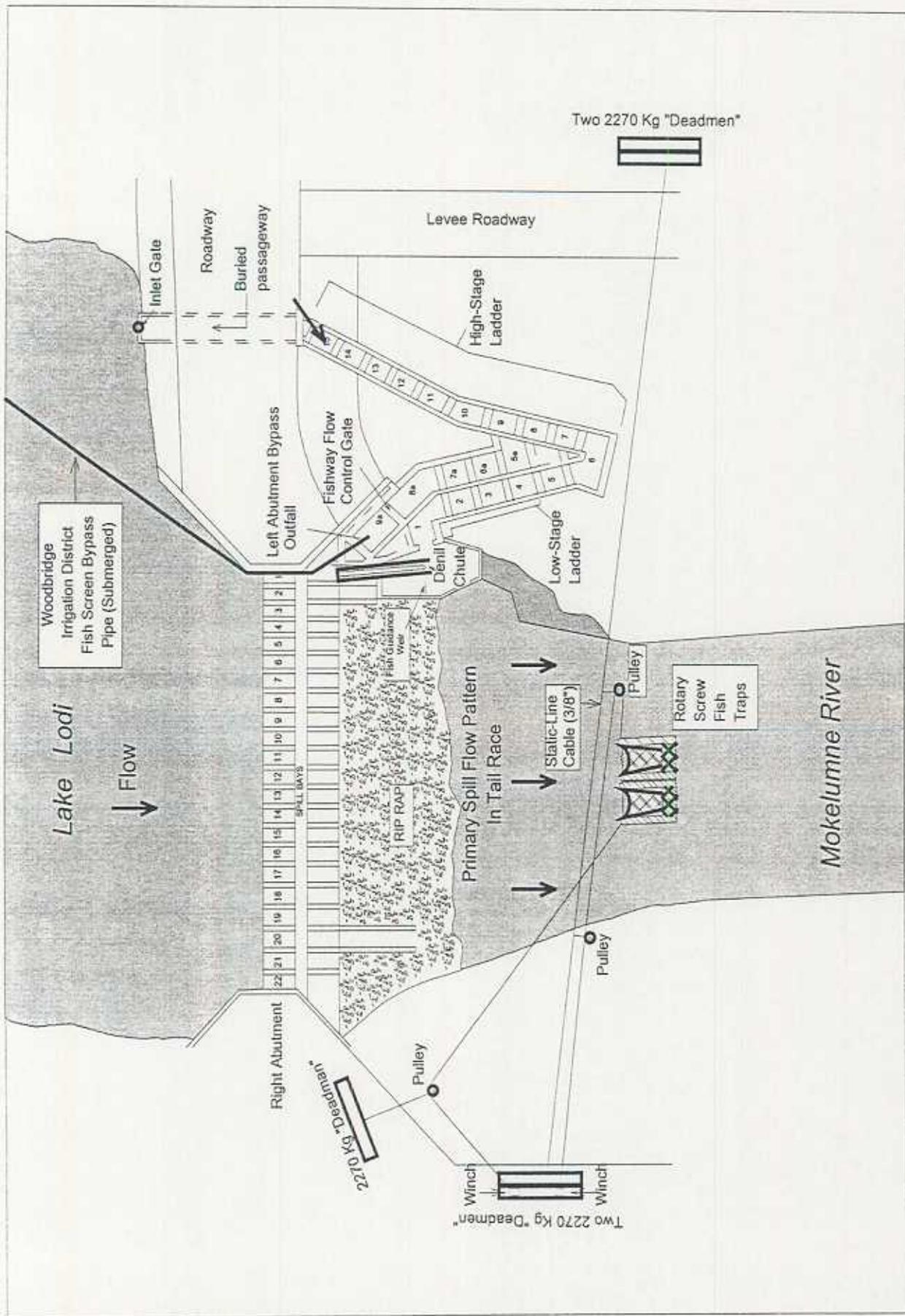


Figure 2. Plan view of Woodbridge Dam showing locations of downstream migrant traps employed during 1998.

(DO) during the processing procedures. To ensure DO remained at sufficient levels in holding buckets, water was exchanged about every 5 to 10 minutes.

Surface water temperature was measured with a mercury-filled thermometer, water clarity was measured with a secchi disk, and turbidity samples were collected at the trapping site each time traps were attended. Any other relevant biological or environmental conditions potentially affecting trap performance or fish behavior (e.g., incidence of predators, incidence of poaching, debris loads in traps, changes in river flow, or spill configurations at Woodbridge Dam) were recorded when observed.

2.1.3 Trap Maintenance and Debris Management

Riverine and urban-generated debris can impair operation of the rotary screw traps. Of particular importance at the Woodbridge Dam site are large tree limbs and floating lumber. Tree limbs and floating lumber larger than about 40 cm long and 10 cm in diameter entrained into a screw trap usually stopped rotation of the trap. These occurrences required increased trap inspection frequencies and were most common during the stormy winter season and during increases in discharges from Camanche Dam or adjustment of flashboards in Woodbridge Dam. Discarded monofilament fishing line was also a periodic problem especially during episodes of illegal fishing in the vicinity of the dam and traps during the spring and summer months. All debris and fishing line were cleared from the trap at least twice daily and up to four times daily during heavy accumulations. A debris deflecting boom was installed approximately 4 to 6 meters upstream of the traps and tested for efficacy and effects on fish in July 1998.

Algal growth on the perforated rotating cone of the traps was removed by brushing all surfaces as often as twice daily. This algal growth occurred predominantly during the late spring and summer months.

Seals between the interior of the live boxes and the moving parts of the traps were inspected regularly to ensure proper fit and sealing. A vegetable oil-based lubricant was periodically applied to nylon bushings that bear the rotating axle shaft of the trap.

2.1.4 Trap Calibrations for Abundance Estimates

Fish capture efficiency of the rotary screw trap system was measured at twenty-one intervals during the monitoring period to encompass the range of changes in fish sizes, river stage, turbidity, and Woodbridge Dam spill conditions. Both hatchery-reared and wild juvenile salmon used for these mark-recapture tests were of Mokelumne River origin. Fin clips were used to mark fish for these assessments. Fin clips were made by excising a small portion of the upper or lower lobe of the caudal fin while the fish were sedated (ca. 70 to 100 mg/L tricaine solution). Fish were allowed to recover in cylindrical 25-L PVC live cars (30 cm diameter, 40 cm long with soft nylon 2-mm Delta mesh covered ends) placed in a protected refuge in the low-stage fishway

for 6 to 24 hours before their release for the tests. A sample of 30 to 50 fish from each release group was measured for FL and examined for mark quality before release.

Paired test releases, one during daylight (1-hour after sunrise to 1-hour before sunset) and one during night time (½-hour after sunset to ½-hour before sunrise), were generally made for each trap efficiency measurement interval. Marked fish were released at the crest of the spill over flashboards on Woodbridge Dam, or near the fishway discharge (Figure 2). Fish released into the spill crest were liberated on the spill crest's falling portion so that none escaped upstream into Lake Lodi. These release groups were divided into four or five groups of approximately equal sublots and released across the entire width of the dam's spillway. The hydraulic head differential between the upstream and downstream side of the dam ranged from zero to about 2.0m. We assumed that the release distance from the trap and the spill configuration of the dam's discharge allowed fish to seek a preferred portion, or natural migration route, or to mix to a homogeneous distribution within the river flow before encountering the traps.

2.2 Abundance and Timing of Emigration

The numbers of each salmonid species within each age class captured were stratified by day and night and compiled daily. Morning (night) and afternoon (day) trap capture numbers were combined to provide daily totals. Daily counts were compiled into weekly totals for several analyses. Outmigrant young-of-year (YOY) chinook salmon abundance estimates were generated from trapping efficiency results. Diurnal and nocturnal abundances were estimated daily using the day and night trap efficiency rates, respectively, and summed to produce daily total abundances. Abundance for each discrete period was estimated using the calculation:

$$\text{Est. Abundance} = [\text{number of salmon captured}] \div [\text{trap efficiency for applicable period}].$$

For each day, nocturnal abundance estimates included fish passing during the full darkness and the crepuscular periods (dusk and dawn) of the preceding night; and, diurnal abundance estimates included fish passing during full daylight, generally 1 to 2 hours after sunrise until 1 to 2 hours before sunset. Rotary trap abundance estimates were summed with the numbers of salmon captured in the fishway-installed downstream migrant traps to generate daily abundance estimates when these traps were operated.

2.3 Fish Size and Condition

Sizes (FL, TL) and weights obtained from subsamples of up to 60 salmonids per trap in each day's trap catches were compiled. Fulton's Condition Factor, given as $(100 \times \text{weight}/\text{TL}^3)$ by Bagenal and Tesch (1978), where weight is in grams and TL is in millimeters, was computed for each fish. Daily and weekly averages for FL, TL, weight, and condition factor of YOY and yearling salmon were computed and analyzed. Salmon fry were classified as those with $\text{FL} \leq 50$ mm based on a general size criterion for ocean-type chinook salmon throughout their range (Healy 1991).

Injuries on trapped fish were described, recorded, and compiled daily, as well as the numbers of dead fish found in the traps. Incidents of injury and mortality were examined with regard to effects of predators, debris fouling of the traps, and other conditions that may have contributed to their occurrence.

2.4 Physical Environmental Data

Daily environmental data for the period December 1997 through July 1998 were obtained from the following sources:

- River Flow passing Woodbridge Dam: U.S. Geological Survey (USGS) gauging station (11325500) on the Mokelumne River located downstream of Woodbridge Dam near River Kilometer 60.
- WID's Canal Diversions: USGS gauging station (11325000) located in the canal near the point of diversion at Woodbridge, California.
- Local Watershed Precipitation: National Weather Service field data collection station at Camanche Dam, San Joaquin County, California; and a Campbell Scientific Instruments meteorological datalogger² at Woodbridge, California.
- River Temperature at Woodbridge Dam: Ryan Model RTM 2000 thermograph³ installed in pool No. 6a of the low-stage fishway or pool No.15 of the high-stage fishway and surface temperatures generally measured twice daily, in the morning and in the afternoon, with a mercury-filled thermometer.
- Water Turbidity Index (Secchi Depth): Generally measured twice daily in the river channel off downstream end of screw traps, or in Lake Lodi immediately upstream from spillbay 1 at Woodbridge Dam. Measurements of nephelometric turbidity units (NTU) were measured using a Hach® turbidimeter on water samples collected twice daily at Woodbridge Dam.
- Lunar Age and Regional Sunrise/Sunset Timing: *1997/1998 Old Farmer's Almanac*, Yankee Publishing Inc., Dublin, New Hampshire.
- Sacramento-San Joaquin Delta Water Conditions: U.S. Bureau of Reclamation, Central Valley Operations Coordinating Office, Sacramento, California and California Department of Water Resources, Sacramento, California.

²Campbell Scientific Instruments, Inc., Logan, Utah

³Ryan Instruments Inc., Redmond, Washington

2.5 Diel Migration Pattern Surveys

Diel migration behavior patterns of fall-run chinook salmon smolts were assessed during the peak emigration period. Diel surveys were conducted at the Woodbridge Dam trap site on April 21-22, May 05-06, May 19-20, and June 09-10, 1998. Traps were tended hourly for 24 hours during these surveys using the previously described fish handling and trap tending protocols. Numbers of juvenile salmon captured during each of the diel surveys were compiled on an hourly basis. Diurnal and nocturnal trap efficiencies were applied to hourly trap captures to compute hourly estimated abundances of downstream migrant salmon smolts during the survey periods.

2.6 Coded-Wire Tagging of Wild Smolts at Woodbridge Dam Trap Site

Naturally produced juvenile salmon >40 mm FL captured in the traps were coded wire tagged from March 01 through August 02, 1998. A 3 meter long Wells Cargo® trailer outfitted with two marking stations, each with a NMT⁴ Mark IV tagging machine, quality control device (QCD), and recirculating anesthetic bath, and a flow-through fiberglass holding tank supplied with pumped river water was stationed at the trapping site. Fish were tagged with one-half millimeter binary CWTs (microtags) injected by the tagging machine into the head cartilage and marked by excision of the adipose fin using Miltex® fine-tipped surgical scissors. Fish were handled, as previously described for fish handling and measurement, with the additional procedures of injecting CWTs, excision of the adipose fin, and passing fish through a QCD or field microtag detector to ensure tag implantation before their placement into a recovery tank of fresh, flowing river water. After recovery, fish were released approximately 100 m downstream from the trap.

The quality of tagging and latent mortality associated with handling during tagging were assessed at eleven intervals. Approximately, 30 tagged fish were placed in 25 L PVC live cars (previously described) at densities of about 5-10 fish per live car and held in a protected area of the fishway for 5 to 7 days. The live cars were checked daily for mortalities. At the end of the holding period, all fish were mildly sedated with tricaine (*ca.* 30 to 50 mg/l), examined for quality of the adipose fin clip, and passed through the microtag detector to confirm tag retention. After this procedure, all fish were released as previously described.

2.7 Coded-Wire Tagging of Hatchery Smolts and Delta Survival Experiments

A 9 meter long Wells Cargo® trailer outfitted with CWT equipment was used to tag chinook salmon smolts reared at the MRFI for mark and recapture experiments of smolt survival in the Sacramento-San Joaquin Delta. The trailer was equipped with five marking stations (as previously described). A stainless steel trough running along the length of an interior wall of the trailer was supplied with continuously flowing water pumped from a hatchery water supply for

⁴Northwest Marine Technologies, Shaw Island, Washington.

loading and holding fish in the trailer prior to being tagged. A PVC return pipe manifold system that ran the length of the trailer's floor passing beneath each station served to collect and carry tagged fish outside to a receiving raceway. Each station was plumbed to receive water pumped from the hatchery water supply. This plumbing system provided water to operate the QCD's hydraulic sorting switches, which separated correctly tagged from untagged fish, and to carry tagged fish through the return pipe system. The trailer was also equipped with a recirculating anesthetic system. This system consisted of a 120 L plastic barrel supply tank, aerator, and submersible pump for pumping anesthetic solution through a heat exchanger in the bottom of the flow-through holding tank, then to a PVC distribution manifold leading to each station. Anesthetic solution returned to the supply tank through a return pipe for reconditioning.

Tagging procedure: Fish were loaded directly from the hatchery raceway into the trailer's holding trough from which fish tagging technicians netted groups of fish. Groups of about 50 to 60 fish were mildly anesthetized in aerated, buffered, tricaine methane sulfonate solutions (*ca* 70 to 90 mg/L, buffered *w/w* with sodium bicarbonate). The temperature of the anesthetic solution at each station was monitored regularly. The anesthetic solution was changed at 2 to 3 hour intervals or more frequently if the time for induction of anesthesia increased to more than about 1.5 to 2 minutes. Once the fish were anesthetized, a 1mm binary CWT was injected into the head cartilage of each fish using the tagging machine, the adipose fin was excised with a pair of fine-pointed surgical scissors, and the fish was passed through the QCD. Fish which the QCD detected as untagged were automatically directed to a recovery bucket and the QCD issued a warning tone to the operator. These fish were passed back through the QCD to check the rejection and retagged if necessary. Efficiency of tagging, proper operation of QCD's, and tag placement for each operator and tagging machine was checked two to three times daily during tagging operations. Samples of 25 to 100 fish were collected from each station's QCD outflow and passed back through another QCD for confirmation of tagging efficiency and QCD operation. A subsample of 3 to 10 of these fish was dissected to confirm proper placement of the tags and the tagging machines were adjusted if necessary. Machine cleaning, repair or adjustment was conducted at the end of each tagging day.

Approximately 208,000 smolts at a size of about 200 fish per kilogram were tagged for the 1998 Delta survival study. These Mokelumne River origin fish were incubated, hatched, and reared at MRFI. Four tag codes assigned to EBMUD were used during March 21 to April 3, 1998 to tag these fish. The tag codes were allocated to four groups of about 52,000 fish each. Two tag codes were allocated to each of two experimental release groups. This experimental design required a compromise on independence of the replicate experimental groups due to space and manpower constraints at MRFI. Therefore, the paired CWT groups were treated as sublots, since, while reared separately, they were transported and released together to the release sites by CDFG. The resulting CWT release groups were as follows:

<u>Experimental Group</u>	<u>Release Site</u>	<u>Tag Codes</u>
"Test"	Mokelumne River - Thornton	06-02-32 and 06-02-33
"Control"	San Joaquin River - Jersey Point	06-02-34 and 06-02-35

The duplicated subplot releases allowed for a limited estimation of within treatment sampling variance ("internal variance") to assess reliability of survival estimates for each experimental release (Burnham et al. 1987).

During the holding period prior to release, CDFG maintained records of all mortalities in each of the tag code groups. Each of the tag groups were checked for tag retention and quality of fin clip 19 to 26 days after being tagged, which was within one to two days of release. Samples of about 300 fish⁵ for each of the tag groups were mildly sedated in a 50 mg/l solution of tricaine, examined, and individually passed through a microtag detector set up alongside the raceway. Thirty to fifty fish were measured (FL and TL) and weighed and their condition factors were calculated. Then following the procedure outlined by CDFG, the proportion of fish detected without tags for each sample was used to adjust for total numbers of fish retaining tags after subtracting mortalities from the number originally tagged (F. Fisher, CDFG, personal communication).

CDFG transported and released each of the composite tagged groups of fish. The "test" group, 06-02-32/33, was released at New Hope Landing near the confluence of the mainstem Mokelumne River and the central Delta on April 21, 1998 (Figure 1). The "control" group, 06-02-34/35 was released at Sherman Island across from Jersey Point on the San Joaquin River near its confluence with the Sacramento River on April 28, 1998. A group of 30 to 50 released fish were dip-netted and retained in 25 L live cars for 24 hours to observe post-stocking mortality. Marked experimental release groups were recaptured by the U.S. Fish and Wildlife Service's (USFWS) Sacramento-San Joaquin Estuary Fishery Resource Office using a standardized, routine trawl sampling program at the western outflow of the Delta near Chippis Island (P.L. Brandes, USFWS, Stockton, California, personal communication). USFWS processed recaptured fish and identified CWT samples. Reports of incidental recoveries at the Central Valley Project/State Water Project (CVP/SWP) diversion's fish salvage facilities, the Real Time Monitoring Program, and other Interagency Ecological Program sampling projects were obtained as well.

2.8 Coded-Wire Tag Summaries and Assessment

Data for both wild and hatchery-reared groups included initial numbers of fish tagged, tag retention, post-tagging mortality, size of fish at time of release, dates of release and release objectives. These data were submitted to CDFG in their reporting format during May to

⁵This sample size was derived as sufficient to provide an estimate of tag retention with a 95% confidence interval within $\pm 3\%$ of the actual mean.

December 1998. Tagging data for wild and hatchery release groups are presented in this report. Tag recovery data for the Delta survival experimental releases were compiled by USFWS. USFWS provided computed survival indices (S_T) for each of the tag codes recovered during their surveys. These data were evaluated for statistical validity by comparing homogeneity of subplot recoveries using Chi-square analysis.

III. RESULTS AND DISCUSSION

3.1 Fish Abundances Monitored at Woodbridge Dam

3.1.1 Numbers of Fish Trapped

Trapping was conducted for 229 days from December 15, 1997 until August 02, 1998 at Woodbridge Dam. Appendices A and B provide daily records of traps used, trapping effort, and the numbers of juvenile fall-run chinook salmon and steelhead captured. Table 1 shows the monthly distribution of thirty-two species captured at Woodbridge Dam. Juvenile chinook salmon were the most abundant species. The most abundant non-salmonid species captured were non-native cyprinids (minnow family) and centrarchids (sunfish family), and native prickly sculpin (*Cottus asper*) and juvenile and larval Pacific lamprey (*Lampetra tridentata*). In general, the life stages of all species captured were juveniles and subadults. Some adults of the smaller sized species, such as prickly sculpin, golden shiner (*Notemigonus crysoleucas*), and smaller sunfishes were captured as well.

3.1.2 Abundance Estimate for Downstream Migrant Juvenile Chinook Salmon

Abundance estimates for YOY fall-run chinook salmon were based on 20 trap calibration intervals during the season (Table 2). Ten of seventeen paired day and night trap efficiency tests resulted in significantly different (chi-square, 1 *df*, $\alpha \leq 0.05$) day-night trap efficiencies. When diel efficiencies were different, traps were more efficient during the day for both fry ($FL \leq 50\text{mm}$) and smolts ($FL > 50\text{mm}$). So, daily abundance estimates were stratified by day and night time periods for computations.

Differences in diel capture probabilities of rotary fish traps for downstream migrant chinook salmon have been reported for previous years on the Mokelumne River (Vogel and Marine 1998), the South Fork Umpqua River, Oregon (Roper and Scarnecchia 1996), and the Stanislaus River, California (Scott Spaulding, USFWS, personal communication). These differences vary within and among years as well as among trap sites. No consistent trends relating diel differences in trap efficiency to physical or biological environmental conditions have been observed. Therefore, we recommend continuation of frequent paired day and night experimental releases of marked fish for determining trapping efficiency.

Table 1. Numbers of each fish species captured at the Woodbridge Dam trap site (December 15, 1997 through August 2, 1998).

Species	Life Stage	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul/Aug
Chinook Salmon (<i>Oncorhynchus tshawytscha</i>)	Age YOY	40	42,783	22,091	4,097	14,845	32,460	10,455	67
	Age 1+	80	2	1	25	5	0	0	0
Rainbow Trout/Steelhead (<i>Oncorhynchus mykiss</i>)	Age YOY	0	0	0	1	4	6	13	26
	Age 1+	170	229	3	13	16	5	7	3
Kokanee (<i>Oncorhynchus nerka kennerlyi</i>)	Juvenile	0	1	1	1	1	0	2	1
Pacific Lamprey (<i>Lampetra tridentata</i>)	Juvenile	0	2,086	3,011	9	6	6	14	5
	Adult	0	6	1	2	1	0	1	0
Sacramento Sucker (<i>Catostomus occidentalis</i>)	Juvenile	0	1	0	1	1	0	0	9
	Adult	0	1	1	1	1	1	2	0
Bluegill (<i>Lepomis macrochirus</i>)	Juvenile	104	164	80	21	39	21	21	17
	Adult	7	62	12	35	74	86	89	17
Largemouth Bass (<i>Micropterus salmoides</i>)	Juvenile	2	0	0	0	0	1	1	0
	Adult	0	0	0	0	1	0	0	0
Striped Bass (<i>Morone saxatilis</i>)	Juvenile	0	1	0	0	1	40	14	10
Spotted Bass (<i>Micropterus punctulatus</i>)	Juvenile	7	12	20	1	4	13	40	62
	Adult	0	0	0	0	0	0	1	0
Redear Sunfish (<i>Lepomis microlophus</i>)	Juvenile	0	0	1	2	1	2	8	0
	Adult	8	15	4	4	49	94	69	12
Green Sunfish (<i>Lepomis cyanellus</i>)	Adult	1	0	0	0	0	0	0	2
Prickly Sculpin (<i>Cottus asper</i>)	Juvenile	6	16	0	0	15	10	271	604
	Adult	17	194	43	27	23	1	2	0
White Crappie (<i>Pomoxis annularis</i>)	Juvenile	0	1	0	0	0	0	0	0
Black Crappie (<i>Pomoxis nigromaculatus</i>)	Juvenile	44	4	1	3	0	0	0	7
	Adult	4	0	2	4	1	5	2	1

Table 1. Numbers of each fish species captured at the Woodbridge Dam trap site (December 15, 1997 through August 2, 1998) (continued).

Species	Life Stage	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul/Aug
Channel Catfish (<i>Ictalurus punctatus</i>)	Juvenile	0	3	3	2	3	1	1	0
	Adult	0	0	0	0	0	1	1	0
White Catfish (<i>Ameiurus catus</i>)	Juvenile	0	1	0	0	0	2	3	5
	Adult	0	0	0	0	0	2	6	1
Brown Bullhead (<i>Ameiurus nebulosus</i>)	Juvenile	0	4	5	0	0	0	0	0
	Adult	1	1	3	0	0	0	0	0
Carp (<i>Cyprinus carpio</i>)	Juvenile	13	0	2	0	0	0	0	0
	Adult	0	8	3	1	3	1	1	7,208
Goldfish (<i>Carassius auratus</i>)	Adult	0	0	0	0	0	1	0	0
Golden Shiner (<i>Notemigonus crysoleucas</i>)	Adult	106	147	20	8	6	11	21	57
Hitch (<i>Lavinia exilicauda</i>)	Juvenile	0	1	0	0	0	0	8	8
	Adult	0	5	2	3	15	8	0	0
Sacramento Squawfish (<i>Ptychocheilus grandis</i>)	Adult	0	1	4	1	1	2	4	0
Threadfin Shad (<i>Dorosoma petenense</i>)	Adult	22	2	30	16	2	4	2	1
American Shad (<i>Alosa sapidissima</i>)	Juvenile	0	0	0	0	0	0	0	1
	Adult	0	0	0	0	0	0	1	0
Bigscale Logperch (<i>Percina macrolepida</i>)	Adult	0	0	0	2	0	0	0	0
Tule Perch (<i>Hysterocarpus traski</i>)	Adult	0	1	1	1	3	0	4	2
Splittail (<i>Pogonichthys macrolepidotus</i>)	Adult	0	0	5	0	0	3	2	0
Mosquitofish (<i>Gambusia affinis</i>)	Adult	2	2	0	0	1	1	0	0
Inland Silverside (<i>Menidia beryllina</i>)	Juvenile	2	0	0	0	0	0	0	0
	Adult	7	5	0	0	0	0	0	0

Table 2. Trap efficiency test results for tandem rotary screw traps fished at Woodbridge Dam during January through July 1998.

Date of Test	Numbers of Marked Fish-Day		Numbers of Marked Fish-Night		Chi-Square day-night	Avg. Fork Length (mm)	Trap Efficiency		River Flow (cfs)	Water Temp. Secchi Depth (deg. F) (cm)	No. Traps	
	Released	Recaptured	Released	Recaptured			Day	Night				
01/03/98	901	173	n/a	n/a	n/a	35.5	0.192	n/a	554	52.0	140	2
01/05/98	423	120	n/a	n/a	n/a	36.4	0.284	n/a	571	50.3	70	2
01/13/98	n/a	n/a	400	45	n/a	36.2	n/a	0.113	647	50.8	40	2
01/21/98	410	62	423	12	8.75 (p<0.001)	36.7	0.151	0.028	697	50.1	100	2
02/09/98	850	14	1000	21	0.51 (NS)	41.4	0.016	0.021	2930	50.8	70	2
02/19/98	1000	26	990	39	2.82 (NS)	44.6	0.026	0.039	3280	50.2	80	2
02/21/98	1000	121	1000	31	7.58 (p<0.001)	40.4	0.121	0.031	3000	49.6	80	2
02/25/98	1000	129	n/a	n/a	n/a	42.9	0.129	n/a	2950	50.3	80	2
03/13/98	998	104	1032	14	6.16 (p<0.001)	37.9	0.104	0.014	2590	49.8	100	2
03/19/98	1088	177	993	48	0.40 (p<0.001)	49.7	0.163	0.048	2170	50.7	110	2
03/24/98	550	105	949	107	7.52 (p<0.001)	55.0	0.191	0.113	1630	51.4	130	2
04/10/98	534	72	540	74	0.01 (NS)	78.6	0.135	0.137	1530	52.7	150	2
04/21/98	486	71	540	59	2.95 (NS)	86.5	0.146	0.109	1520	54.5	150	2
05/14/98	507	88	524	45	7.63 (p<0.001)	98.2	0.174	0.086	1660	55.2	155	2
05/30/98	474	58	457	56	0.00 (NS)	106.2	0.122	0.123	1820	57.5	110	2
06/09/98	503	137	461	65	5.07 (p<0.001)	112.6	0.272	0.141	1810	59.2	140	2
06/25/98	302	6	316	3	1.16 (NS)	117.3	0.020	0.009	2590	59.7	145	1
06/30/98	582	42	604	11	0.20 (p<0.001)	119.2	0.072	0.018	3170	59.4	95	2
07/14/98	632	22	612	5	0.39 (p<0.001)	110.3	0.035	0.008	2680	60.4	180	2
07/27/98	301	32	329	42	1.04 (NS)	120.5	0.106	0.128	2140	61.7	180	2
08/11/98*	400	21	360	43	1.01 (p<0.001)	80.3	0.053	0.119	1650	n/a	n/a	2

Notes: Recapture period includes two trapping intervals following release (approximately 24h).

Average secchi depths, water temperatures, and stream flows at Woodbridge Dam are for the 24h period immediately following marked fish release.

* Juvenile steelhead were used in this test to verify that their capture probability was within the range observed for YOY chinook salmon.

Average trapping efficiencies were computed for relatively homogeneous time intervals when multiple tests were performed. A time interval was considered homogeneous when river flow, turbidity, spill configuration, fish size, number of traps in service, and observations of predators did not change appreciably. Trap efficiency tests were applied as follows:

Trapping Period	Average Trap Efficiency		Range of River Flows (cfs)
	Day (95% C.I.)	Night (95% C.I.)	
12/15/97 to 02/03/98	0.209 (0.190-0.228)	0.071 (0.054-0.088)	548 - 1,380
02/04/98 to 03/14/98	0.095 (0.086-0.104)	0.024 (0.020-0.028)	1,930 - 3,470
03/15/98 to 03/20/98	0.163 (0.141-0.185)	0.048 (0.035-0.061)	1,990 - 2,350
03/21/98 to 04/09/98	0.191 (0.158-0.224)	0.113 (0.093-0.153)	1,280 - 1,640
04/10/98 to 04/30/98	0.141 (0.120-0.162)	0.123 (0.103-0.143)	1,380 - 1,550
05/01/98 to 06/21/98	0.189 (0.169-0.209)	0.117 (0.101-0.133)	1,520 - 1,990
06/22/98 to 06/26/98	0.020 (0.004-0.036)	0.009 (<0.001-0.020)	1,950 - 2,720
06/27/98	0.072 (0.051-0.093)	0.009 (<0.001-0.020)	3,010
06/28/98 to 07/10/98	0.072 (0.051-0.093)	0.018 (0.007-0.029)	3,070 - 3,190
07/11/98 to 07/16/98	0.035 (0.021-0.049)	0.008 (0.001-0.015)	2,210 - 2,820
07/17/98 to 08/02/98	0.106 (0.071-0.141)	0.128 (0.092-0.164)	1,700 - 2,180

Each day's diurnal and nocturnal abundance estimates for the rotary traps were summed to produce daily total juvenile salmon emigrant abundances. The daily diurnal and nocturnal estimates of abundance, associated mean trap efficiencies, and periods of estimation used to compute the overall abundance estimates are provided in Appendix C.

From December 15, 1997 through August 2, 1998, an estimate of 1,848,539 naturally produced YOY chinook salmon passed the Woodbridge Dam trap site. The 95% confidence interval for this abundance estimate ranged from 1,543,355 to 2,592,219. The infrequent and low daily numbers of YOY steelhead captured precludes reliable estimation of their abundance.

The daily abundance estimates should be considered indices of relative temporal abundance for salmon migrating past Woodbridge Dam (versus passing the rotary trap location). These estimates do not quantify potential fish losses between the dam and the rotary trap location. Actual fish losses between the spill bays, where trap calibration fish are released, and the rotary traps, where trap calibration fish are recaptured, (e.g., attributable to predation) are not known and cannot be separately quantified with these indices.

3.2 Timing of the Downstream Migration of Juvenile Salmonids

Juvenile fall-run chinook salmon (BY97) exhibited a bimodal pattern of emigration in the lower Mokelumne River during 1998 (Figure 3). Fry (FL₅₀mm) migrated in substantial numbers past Woodbridge Dam during January and February followed by relatively few fish in March. Increased numbers of larger juvenile salmon were observed to emigrate beginning around the first of April. These juvenile salmon were composed almost exclusively of smolt-sized fish

(FL>50mm) suggesting the beginning of a purposeful smolt emigration (Figure 4). This bimodal temporal and life stage-specific migration pattern for juvenile fall-run chinook salmon has been reported for the Mokelumne River during several recent years (Vogel and Marine 1994, 1996, 1998a,b, 1999). Figure 5 shows the weekly pattern of YOY fall-run chinook salmon abundance.

Abundance estimates indicate that about 70 percent of the BY97 natural production emigrated as fry during 1998. This estimated proportion of fry emigrants is comparable to that for 1997, but considerably higher than for other years (Vogel and Marine 1999)⁶. The fry migration period occurring principally during January through March was comparable to that observed in previous years (Vogel and Marine 1999). It is common to observe some proportion of a juvenile chinook salmon population to disperse downstream from the spawning grounds shortly after emergence (Healey 1991, Kjelson *et al.* 1982). Hydrologic conditions have been observed to have a great influence on the magnitude of the fry emigration in the Sacramento River with a greater proportion of fry emigrating from upstream river reaches during wet winters with high river flows than during drier years (Vogel *et al.* 1988). However, the destiny of these early migrating fry varies among populations, according to Healey (1991); while some migrate directly to estuaries, others may simply relocate to other suitable freshwater habitat along the river's length.

Yearling-sized chinook salmon were captured and observed at Woodbridge Dam during December 1997 through April 1998, although not in any significant abundance (Table 1). These fish all appeared to be residualized hatchery reared fall-run chinook salmon that were released at Woodbridge Dam in October 1997. Juvenile *O. mykiss* (steelhead/rainbow trout) were not very common at any time during the season except during a one month period following the release of hatchery-reared steelhead smolts below Woodbridge Dam in December 1997 (Table 1). A single *O. mykiss* fry was captured during January 1998. YOY *O. mykiss* were not captured again until after mid-March and only infrequently and in low numbers (Table 1, Appendix B).

⁶Although the 1997-98 monitoring season began 3 to 6 weeks earlier than in previous years, the vast majority of fry were captured after mid-January 1998. And, while downstream migrant trapping began on different dates among monitoring years, monitoring was in place by mid-January in most years. Therefore, we believe comparisons of relative fry abundance between most years can be made with appropriate qualification.

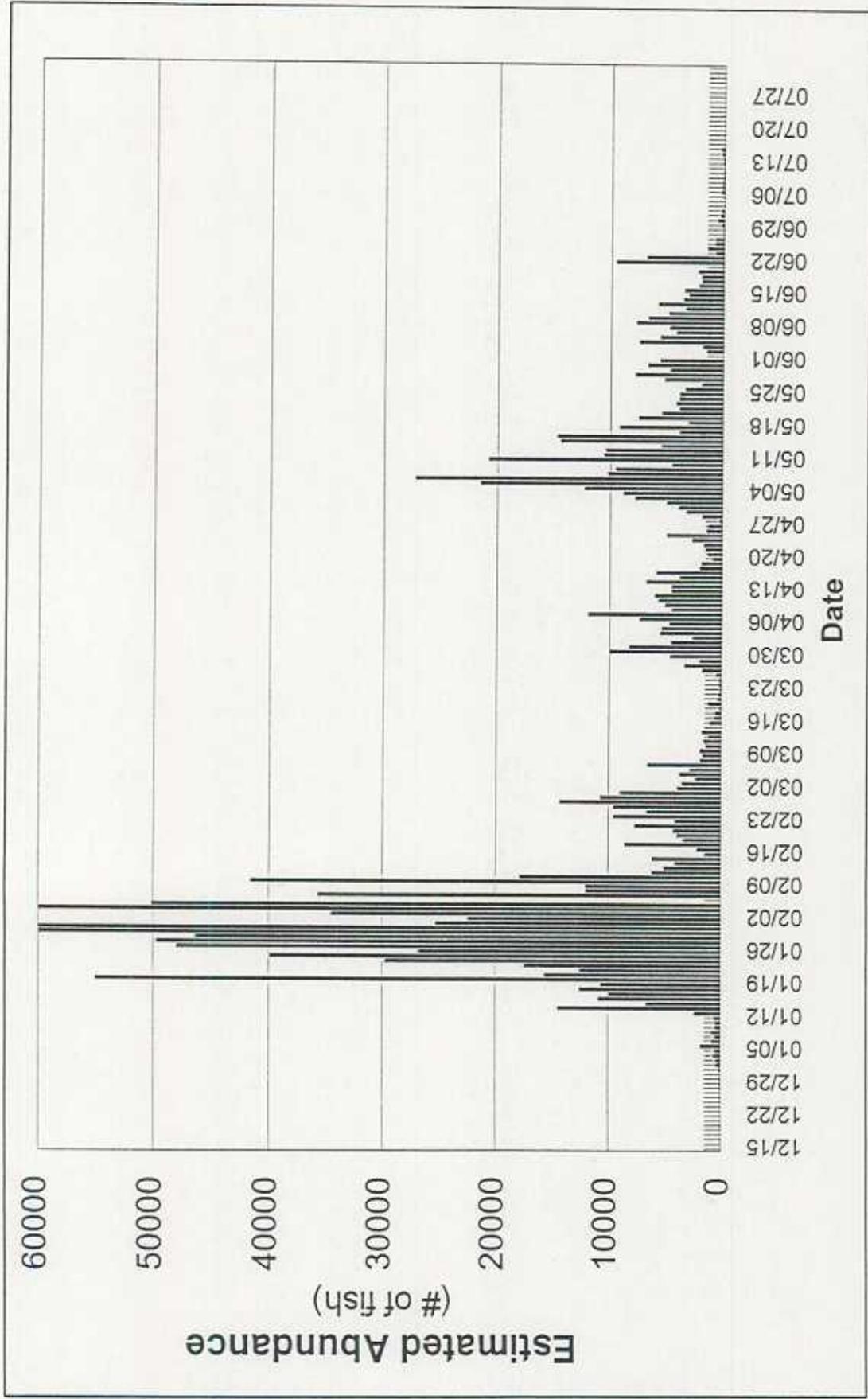


Figure 3. Estimated daily abundance of YOY fall-run chinook salmon passing Woodbridge Dam from December 15, 1997 through August 2, 1998.

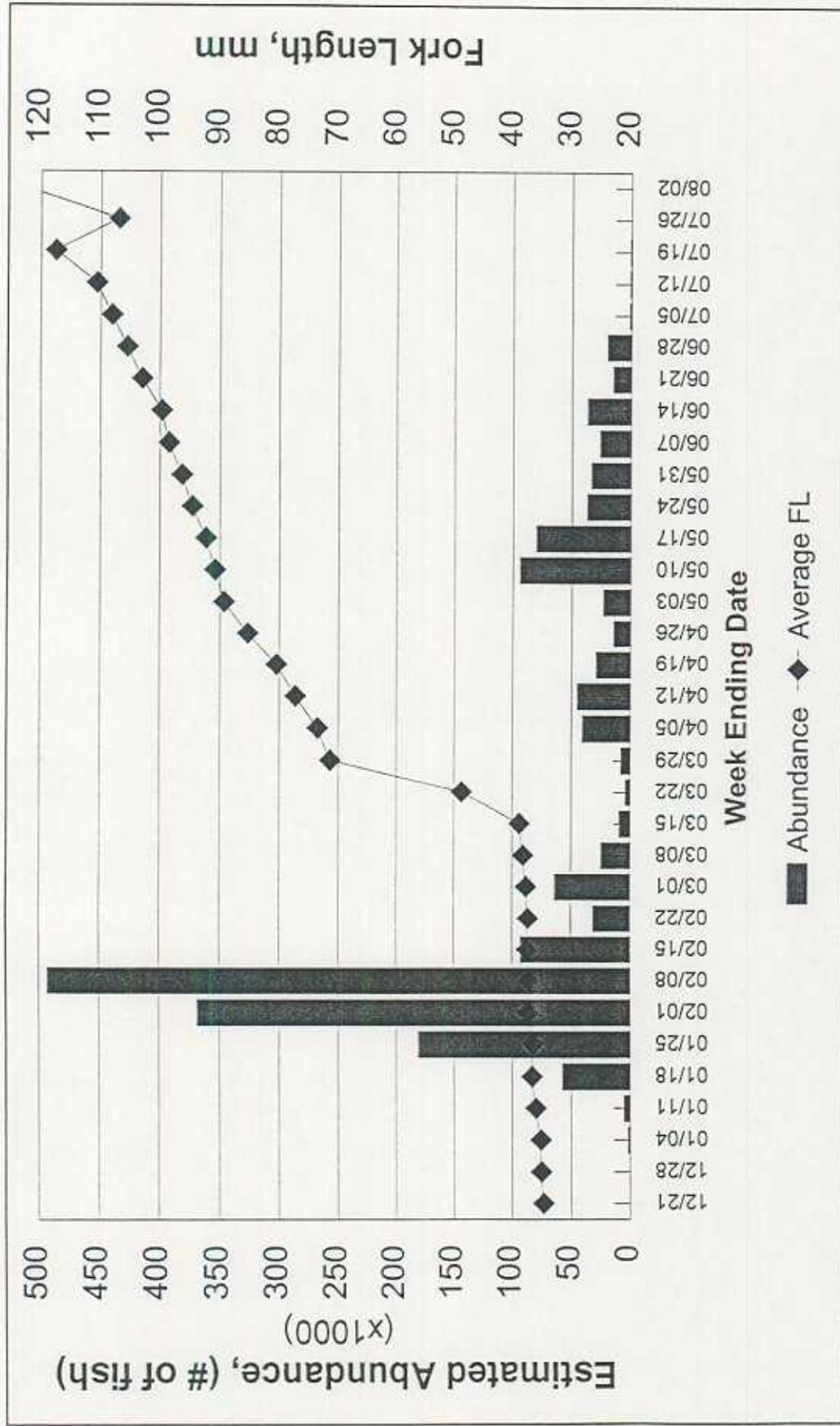


Figure 4. Estimated weekly abundance and mean size of YOY fall-run chinook salmon passing Woodbridge Dam from December 15, 1997 to August 2, 1998.

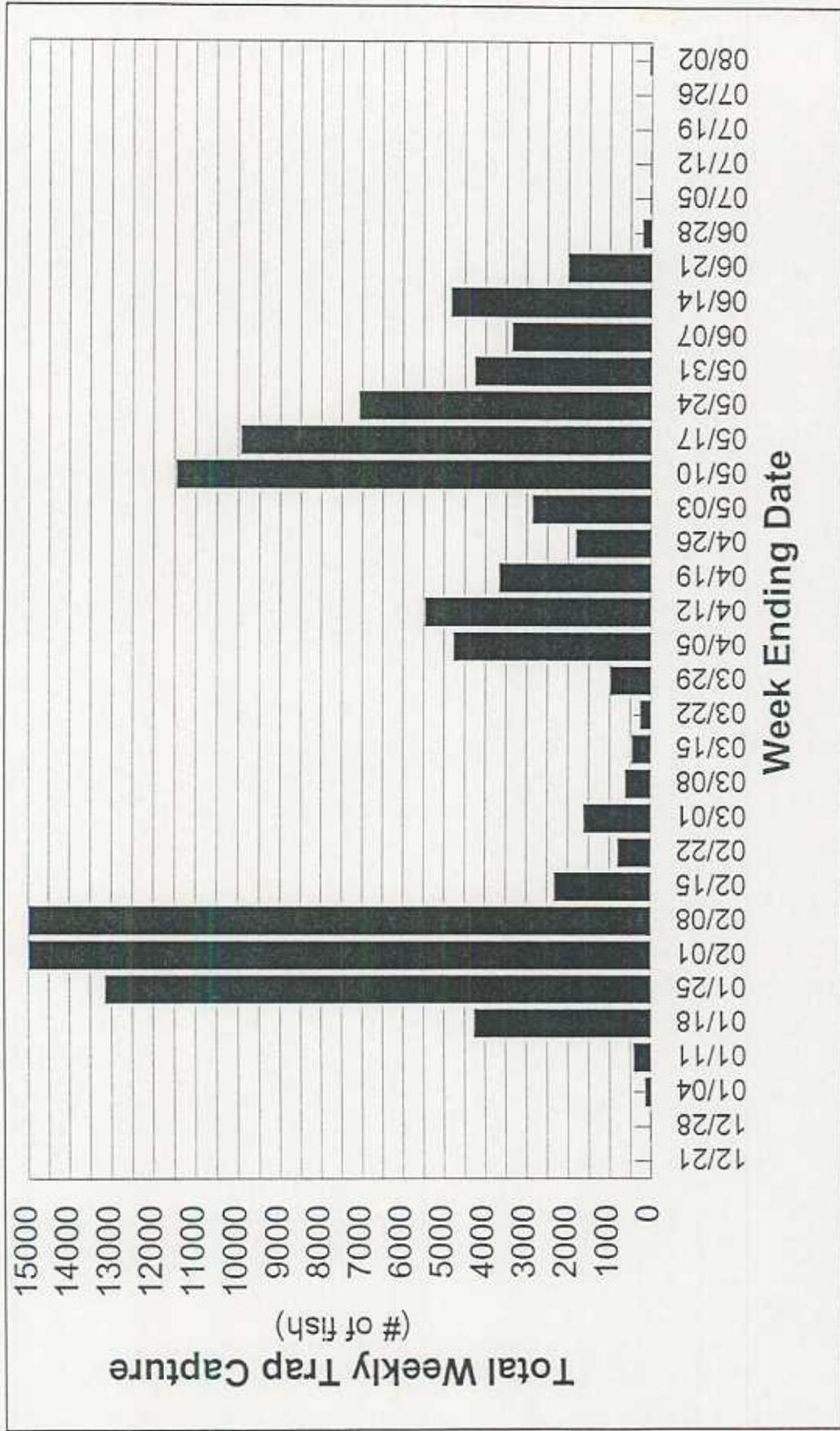


Figure 5. Weekly counts of YOY fall-run chinook salmon trapped in rotary screw fish traps and downstream migrant traps installed in the fishway and fish bypass outfall at Woodbridge Dam on the Mokolumne River from December 15, 1997 to August 2, 1998.

3.3 Size and Condition of Downstream Migrant Salmonids

Daily records of average TL, FL, weight, and condition factor, as well as the range of lengths and weights of salmon captured at Woodbridge Dam are provided in Appendix D. Figure 6 shows the mean and range of total lengths for YOY salmon based on sampling from December 15, 1997 to August 2, 1998. Approximately 70 percent of BY97 production emigrated past Woodbridge Dam as fry and 30 percent as smolt-sized salmon (Figure 4 and Figure 6). As in past years (Vogel and Marine 1994, 1996, 1998a,b, 1999), the number of smolt-sized subyearling salmon increased abruptly beginning near mid-March, signaling the onset of the smolt emigration. Smolt-size salmon predominated catches from the week nearest April 1 through the end of season and no fry were observed after the first week in April. The size of smolts increased gradually for the duration of the season after the onset of this phase of the emigration.

The condition factor of emigrating salmon fry ranged from about 5.1×10^{-4} to 6.8×10^{-4} , with the vast majority ranging from about 6.0×10^{-4} to 6.5×10^{-4} (Figure 7). This range in condition factor of fry is comparable to past years. Yolk-sac fry less than 40mm FL occurred among the earliest emigrants in January and February. Most fry captured during March were post-absorptive (i.e., little to no yolk-sac remaining) fry/parr dominated by fish between 40mm and 50mm FL characterized by increasing condition factors. The abrupt occurrence of large parr and smolt sized salmon in the traps affected increases in the means and the ranges of size and condition measurements during March (Appendix D). The size of smolts migrating by Woodbridge Dam increased throughout the smolt migration. Average condition factor varied, but generally increased over the duration of fry and smolt emigrations (Figure 7). An exception to this trend was the obvious decline in condition factor during the early half of April that coincided with increased captures of smolt-sized salmon. This event was followed by a slow but continuous increase in condition factor during the remainder of the season. This pattern of change in condition factor between the fry/parr and smolt life stages of anadromous salmonids is widely observed. The rather abrupt reduction in "plumpness" characterized by declining condition factor is thought to reflect a change in overall bioenergetic balance associated with the metabolic rigors of salmonid smoltification, as well as, adaptive morphologic changes for life in the ocean (Hoar 1988).

Of 51 YOY *O. mykiss* captured, 2 were fry (FL<40mm) captured in January and March. The majority of YOY *O. mykiss* were captured from mid-April through July and were classified as parr ranging from 50mm to 128mm FL.

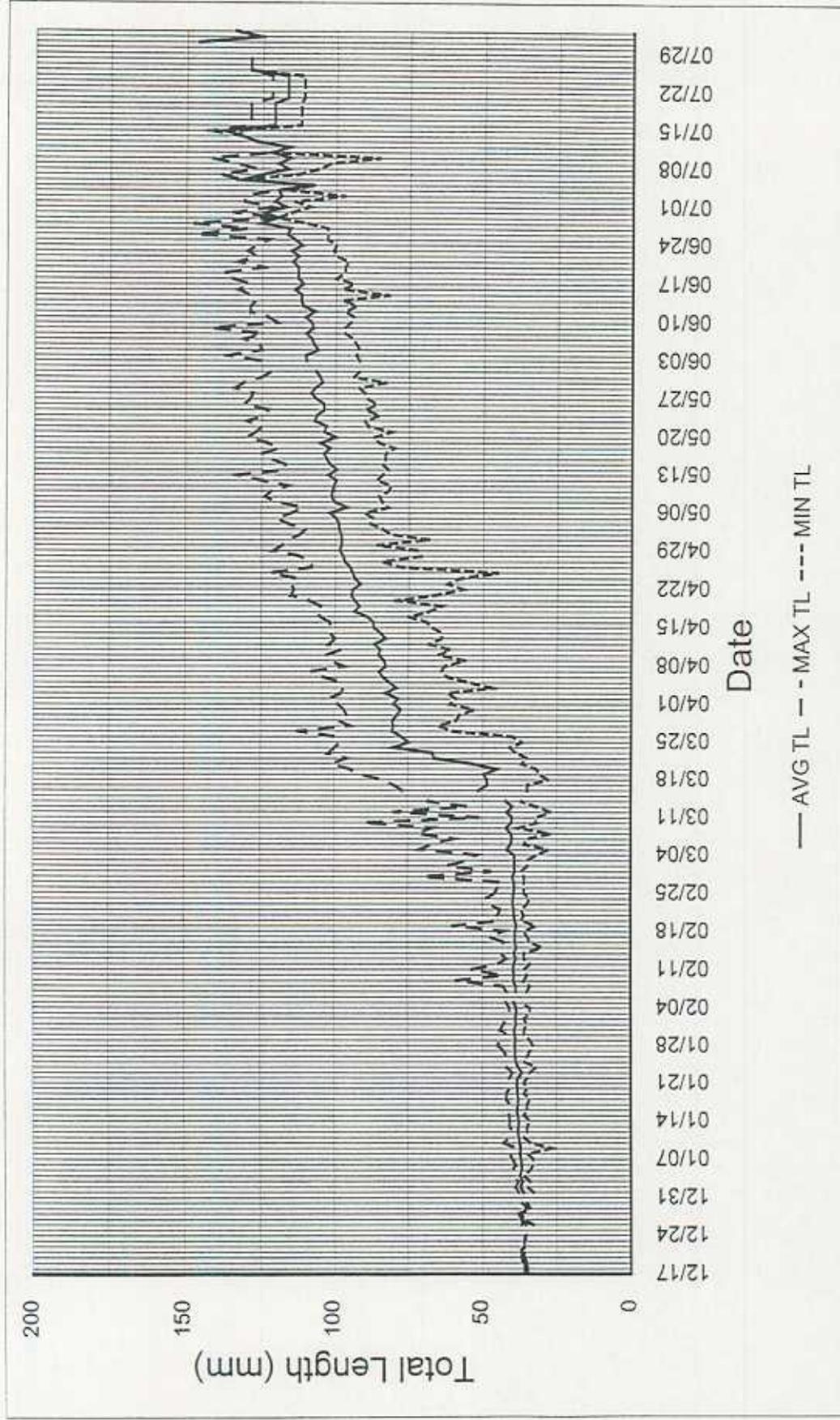


Figure 6. Daily average, maximum, and minimum total lengths of YOY fall-run chinook salmon captured at Woodbridge Dam on the Mokolumne River from December 15, 1997 to August 2, 1998.

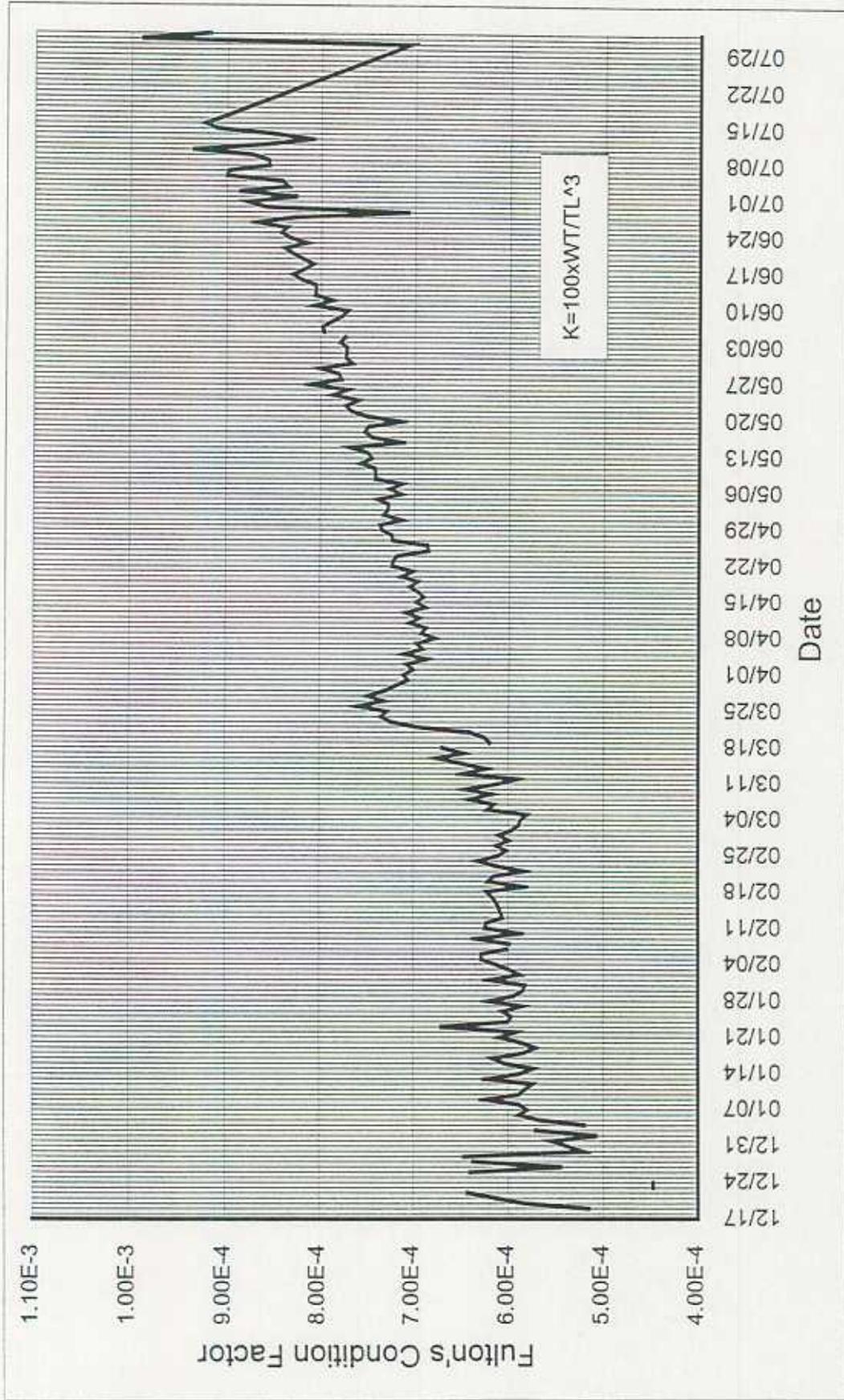


Figure 7. Daily average condition factor (K) of YOY fall-run chinook salmon captured at Woodbridge Dam on the Mokelumne River from December 15, 1997 to August 2, 1998.

3.4 Effects of Physical Environmental Conditions on Downstream Migrants

3.4.1 Diel Periodicity of Fish Migration Past Woodbridge Dam

The hourly patterns of migration of juvenile chinook salmon passing Woodbridge Dam were documented on four occasions during April to June 1998 during the height of the smolt emigration. These results are shown in Figure 8. The majority of fish migrated at night during each of the four synoptic surveys. Crepuscular peaks in passage were exhibited during each survey. This diel migration pattern has been the most common observed for Mokelumne River salmon smolts in over nine years of study since 1990 (Bianchi et al. 1992, Vogel and Marine 1998b, 1999). Only in 1996 and 1997 were any differences observed, when dawn and daytime passage dominated during the latter part of the season (Vogel and Marine 1998b, 1999).

3.4.2 Water Temperature, River Flow, Rainfall, Turbidity, and Lunar Phase

Daily average river flow, water clarity and turbidity, and water temperatures for the Woodbridge Dam trap site are provided in Appendix E. Daily rainfall at Camanche Dam, rainfall and barometric pressure at Woodbridge, California, lunar phase and times of sunrise and sunset are included in Appendix E.

Figure 9 shows the daily river flow, Woodbridge Canal diversions, periods of rainfall, and turbidity at Woodbridge Dam. River flow levels were primarily related to changes in releases from Camanche Dam. Changes in accretions below Camanche Dam were not easily detected at the flow levels occurring during the season. Turbidities varied with transient increases (up to 30-fold) reported during periods of rainfall and river stage changes. January and February storms were associated with the highest turbidities. Increased Camanche Dam releases by themselves were not associated with noticeable changes in turbidity.

Figure 10 shows the hourly water temperatures recorded at the trapping site. Diel fluctuations in water temperatures increased through the season from less than 0.5 °F in December and January to about 2°F in June and July. We computed mean daily water temperatures for comparisons with the daily numbers of downstream migrating salmon (Appendix E).

Some researchers have reported that juvenile salmon emigrations tend to occur in multiphasic peaks or pulses; these pulses may correspond to increased flow, other hydrologic events, and ecological conditions (Healey 1991). For example, research by Kjelson *et al.* (1982) and Vogel (1989) in the Sacramento River reported increased downstream movements of fry chinook salmon corresponding to increased river flows and turbidity. We examined potential migratory responses to these environmental factors and the potential influence of water temperature, lunar phase, and precipitation. As in past years, no general associations of migration abundance corresponding to specific individual factors were apparent (Figures 11 and 12). Peak daily catches of fry almost all occurred during storm events and increased turbidity. However, the magnitudes of rainfall and increased turbidity were not associated with the magnitude of fish abundance. Most changes in migrant abundance appeared to be associated with season or size.

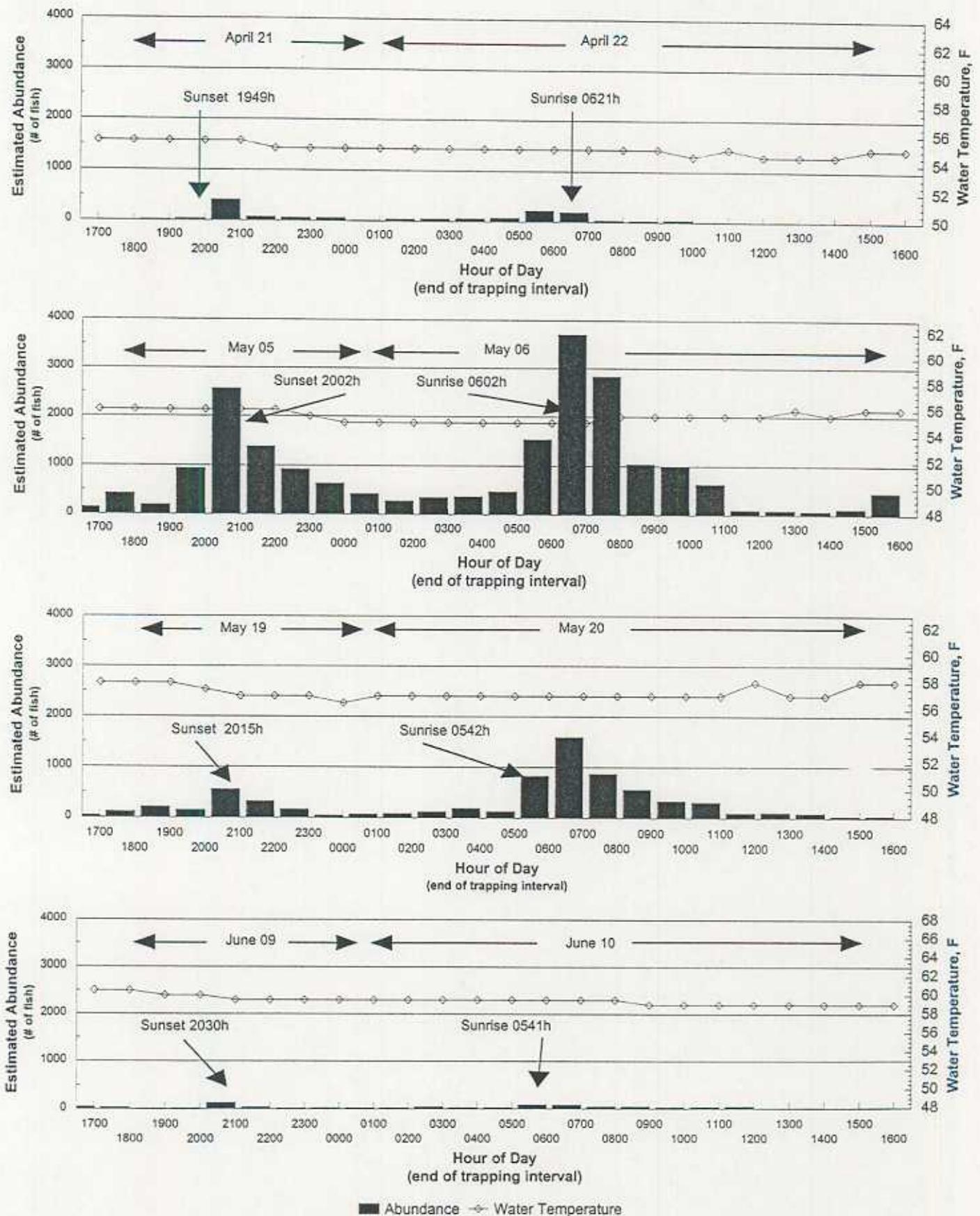


Figure 8. Abundance estimates and water temperatures during diel surveys of YOY fall-run chinook salmon migrating by Woodbridge Dam during April through June 1998.

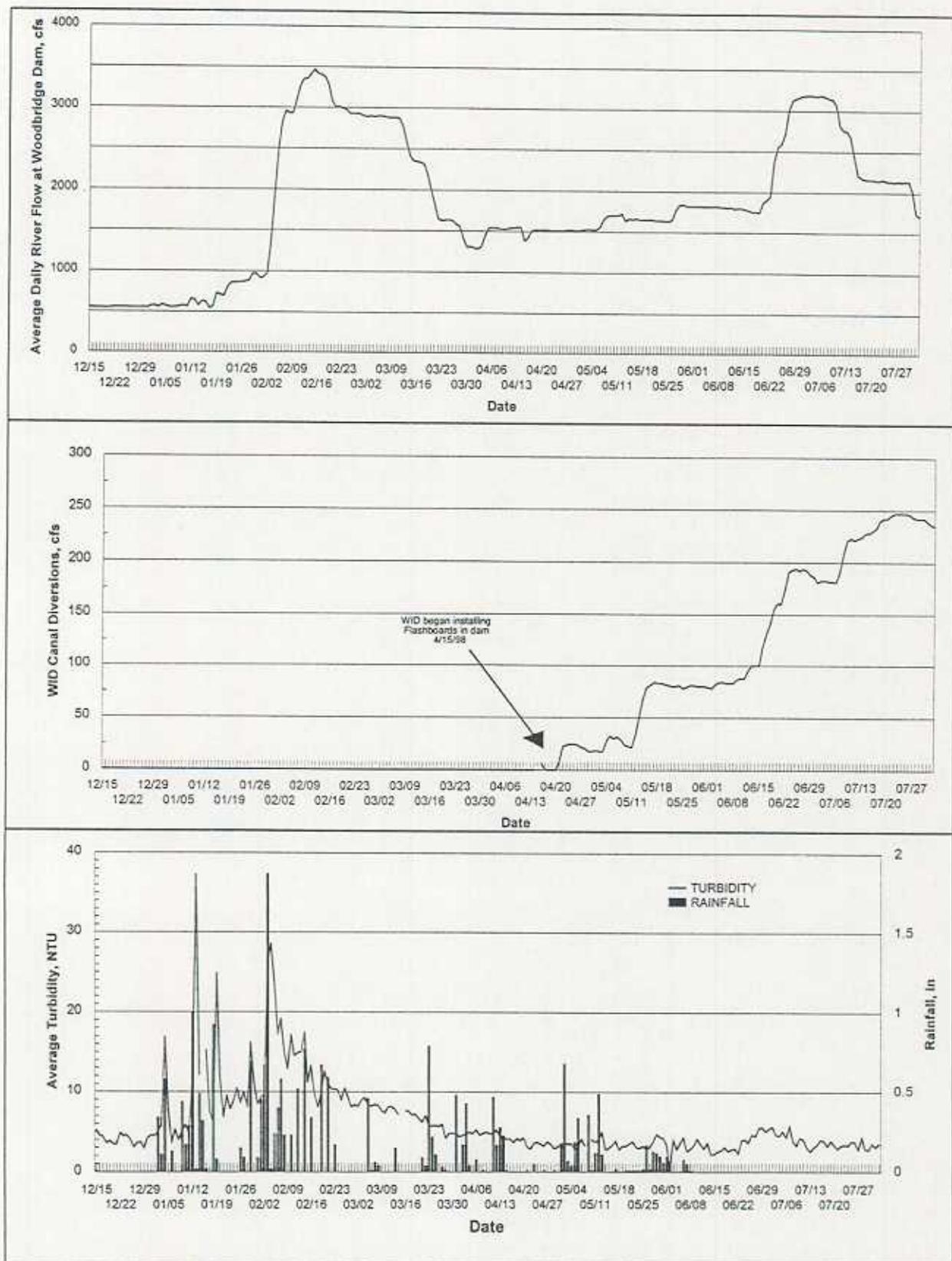


Figure 9. River flow passing Woodbridge Dam, WID canal diversions, daily average turbidity, and rainfall at Woodbridge Dam trap site from December 15, 1997 to August 2, 1998.

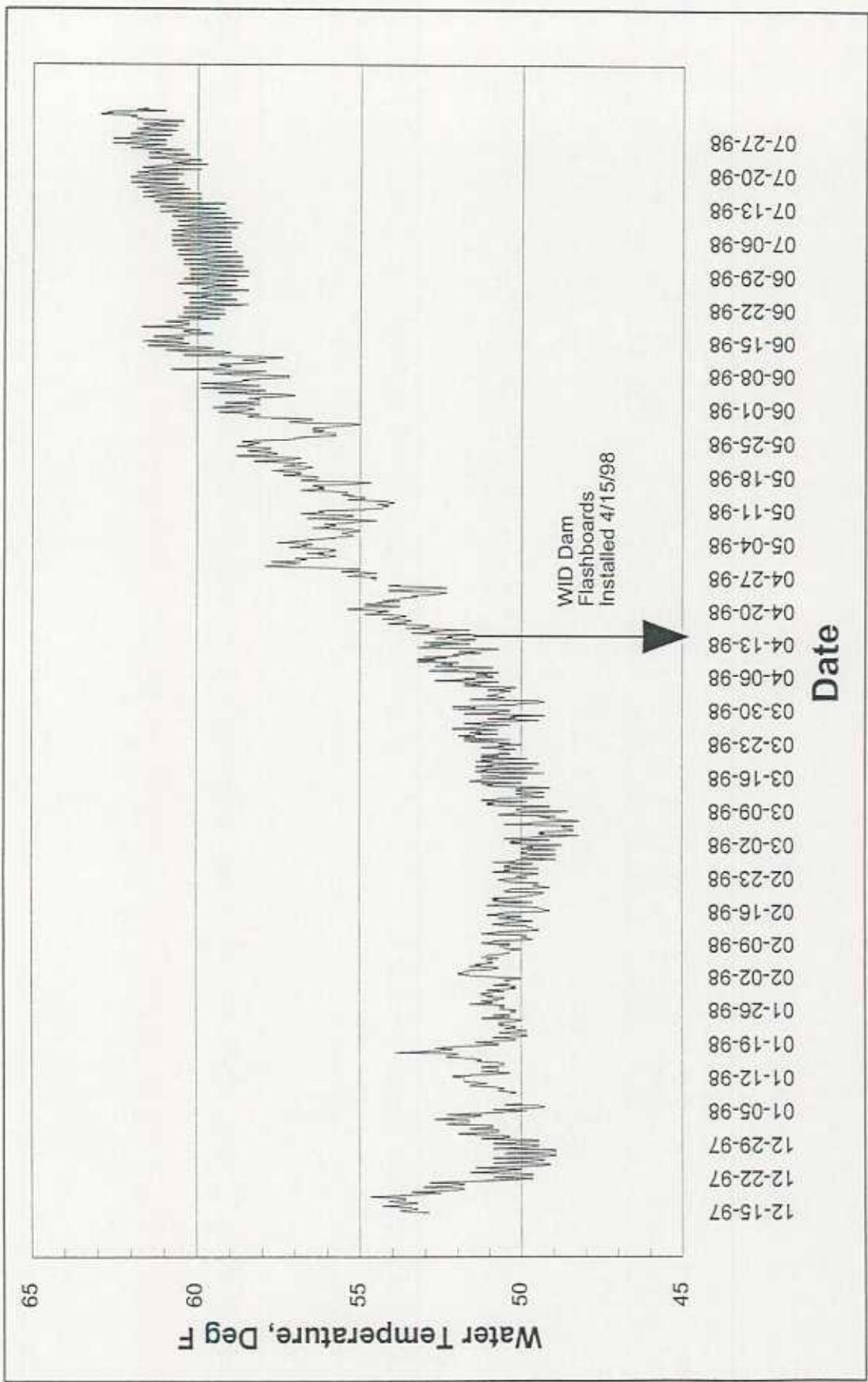


Figure 10. Hourly water temperatures recorded at Woodbridge Dam from December 15, 1997 through August 2, 1998.

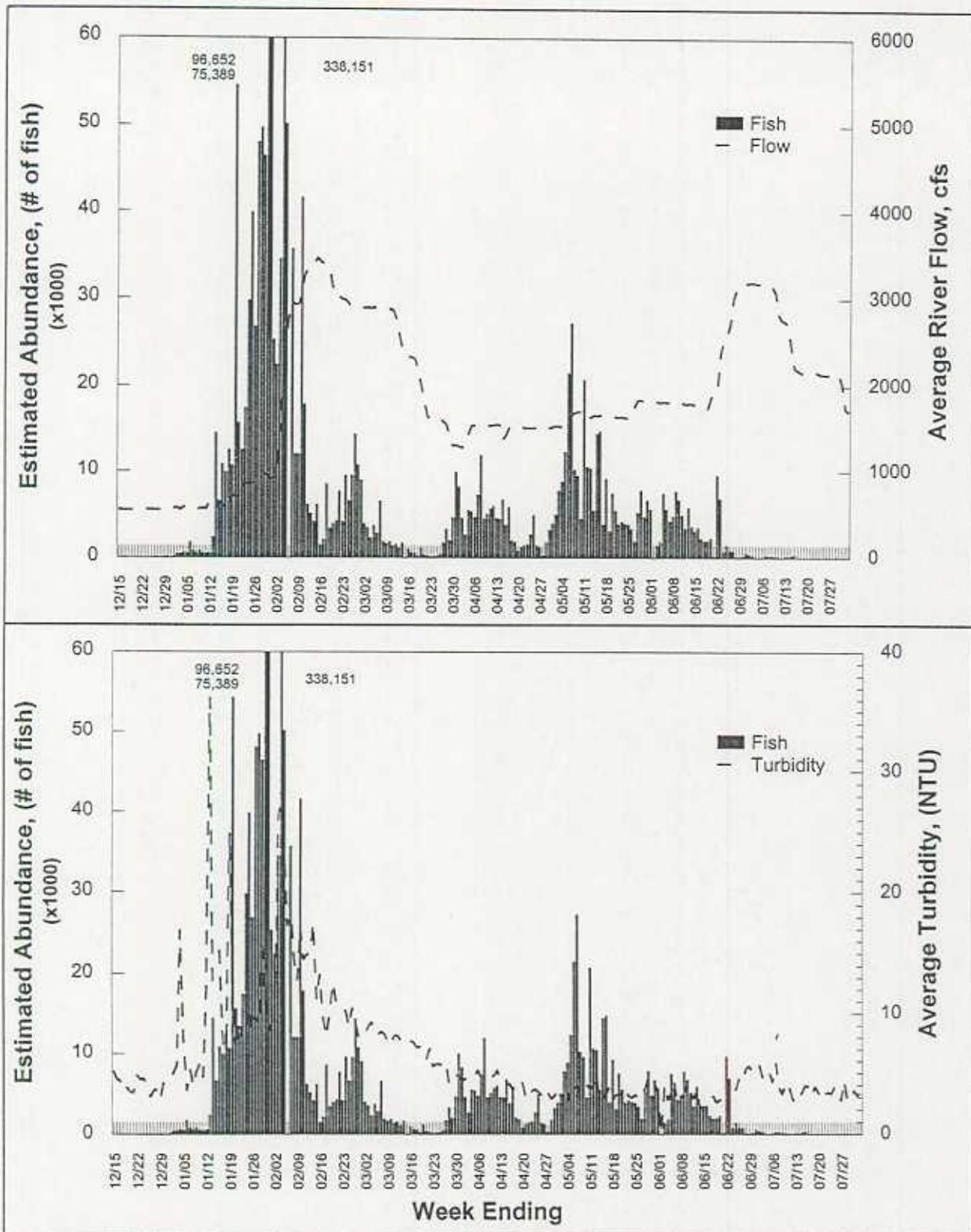


Figure 11. Estimated daily abundance of YOY fall-run chinook salmon passing Woodbridge Dam compared with average daily river flows passing Woodbridge Dam and water turbidity from December 15, 1997 through August 2, 1998. (Abundance values that exceed scale are presented in numeric form).

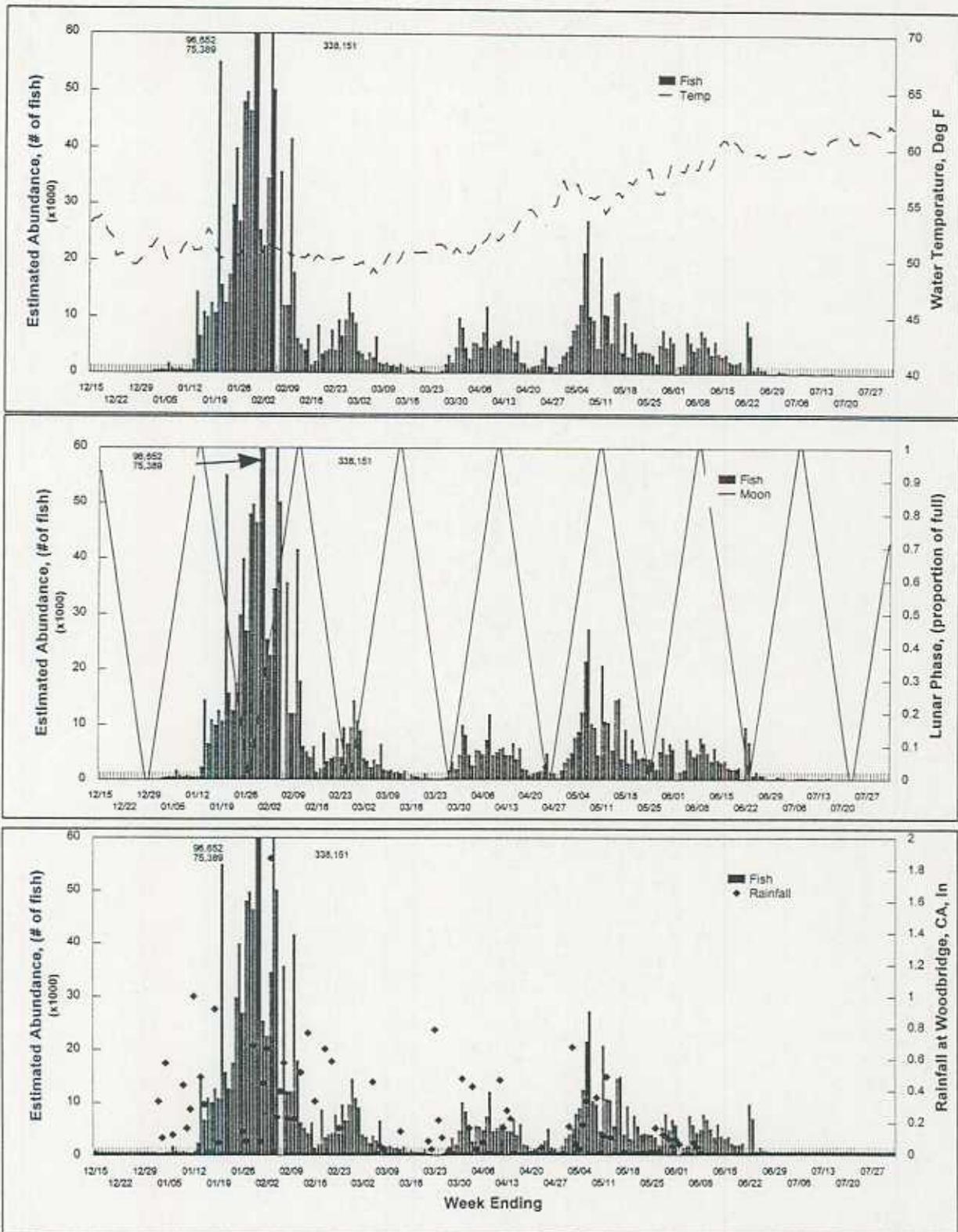


Figure 12. Estimated daily abundance of YOY fall-run chinook salmon passing Woodbridge Dam compared with daily water temperatures, lunar cycle, and daily rainfall measured from December 15, 1997 through August 2, 1998. (Abundance values that exceed scale are presented in numeric form).

This latter pattern is illustrated by the apparent size threshold response denoting the abrupt onset of migrating smolts in April (Figure 4). This "threshold response" is supported by observations of increasing numbers of smolt-sized salmon during April with relatively few intermediate sized salmon (40 - 50 mm FL) occurring in the traps after the subsidence of fry emigration in March.

3.5 Comparison of Annual Juvenile Fall-Run Chinook Salmon Downstream Migrations During 1990-1998

Data for 1998 represent the ninth consecutive monitoring season for juvenile chinook salmon emigrating from the Mokelumne River. Outmigration monitoring methods have changed and have been refined over the years. Outmigration is monitored solely through the fishways under low flow conditions, with use of rotary fish traps when flows are higher, and with combinations of the two methods at intermediate flows. During 1990 -1992, only the fishway traps were used for smolt monitoring. During 1993 - 1998, rotary traps were used for all or portions of the season. And in 1994 and 1997, the fishway traps were fished during portions of the season, at times in combination with the rotary traps. Because of these differences in methodologies between years, direct comparisons among years must be made with some qualifications. However, certain generalized comparisons between years are possible.

The timing of juvenile chinook salmon emigrating past Woodbridge Dam for each year since 1990 is presented in Figures 13 through 15. For the 1998 outmigration season, downstream migrant monitoring was started in December 1997, approximately 3 to 6 weeks earlier than in most years, except for 1994. Salmon fry were intermittently observed in small numbers as early as mid-December 1997 but in significant numbers by mid-January 1998. This pattern contrasts with 1994 when outmigration monitoring was continuous from October 1993 through July 1994. Few fry were captured migrating by Woodbridge Dam during that year (Figure 14). If the patterns for 1994 (a dry year) and 1998 (a wet year) reflect a normal range of fry emigration in the Mokelumne River, then past years with monitoring start dates by the third week in January may be compared for juvenile fall-run chinook salmon emigration timing and relative abundance.

Fry emigrant abundance varies but has dominated that of smolts for each year since 1995. This pattern differs from the emigration timing exhibited in 1993 and 1994. The onset of smolt emigration begins from the latter half of March through early April. The timing of the peak smolt emigration varies within about ± 2 -3 weeks during May and June, but the duration of this migration period varies more between years. River flows during 1990, 1991, 1992, and 1994 were substantially lower during the principal migratory period than river flows in 1993 and 1995 to 1998 (Bianchi *et. al.* 1992, Vogel and Marine 1994,1996, 1998, 1999). Water temperatures recorded in 1991 and 1992 at Woodbridge Dam were approximately 1 to 5 °F higher than during comparable periods in later years (Bianchi *et. al.* 1992) . Water temperature data for 1990 were not available. Higher daily water temperatures during the early part of the smolt migration period may partially account for the earlier smolt-sized salmon outmigrations observed in 1991 and 1994 (data in Bianchi *et. al.* 1992, Vogel and Marine 1994, 1996, 1998a,b, 1999).

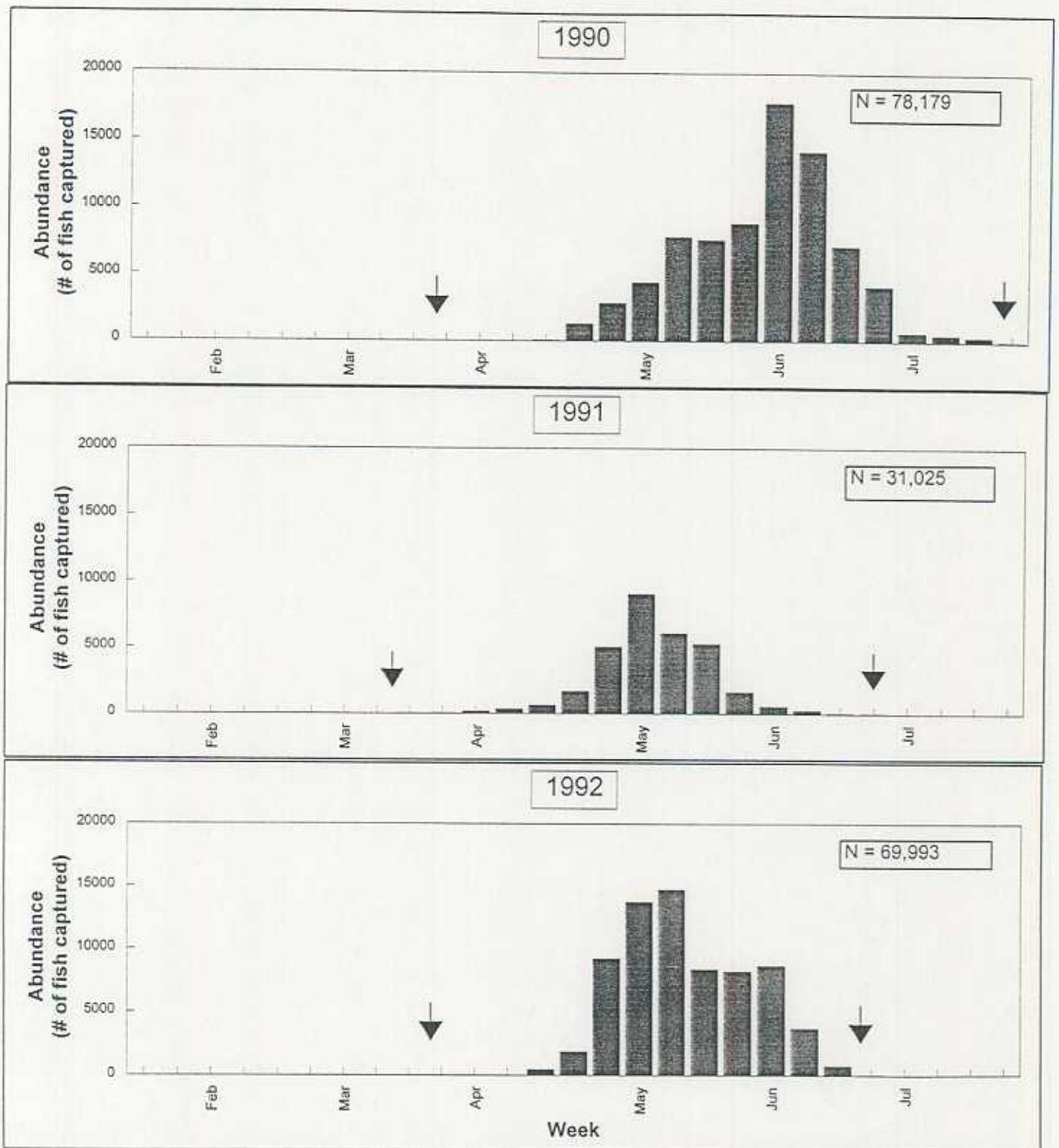


Figure 13. Weekly abundance of downstream migrant fall-run chinook salmon at Woodbridge Dam for 1990-1992. (Abundance for 1990-1992 was determined by capturing fish in fishway traps with nearly 100% of river flow passing through fishways) Month labels are on middle week of each month. Arrows indicate the beginning and end of annual monitoring periods.

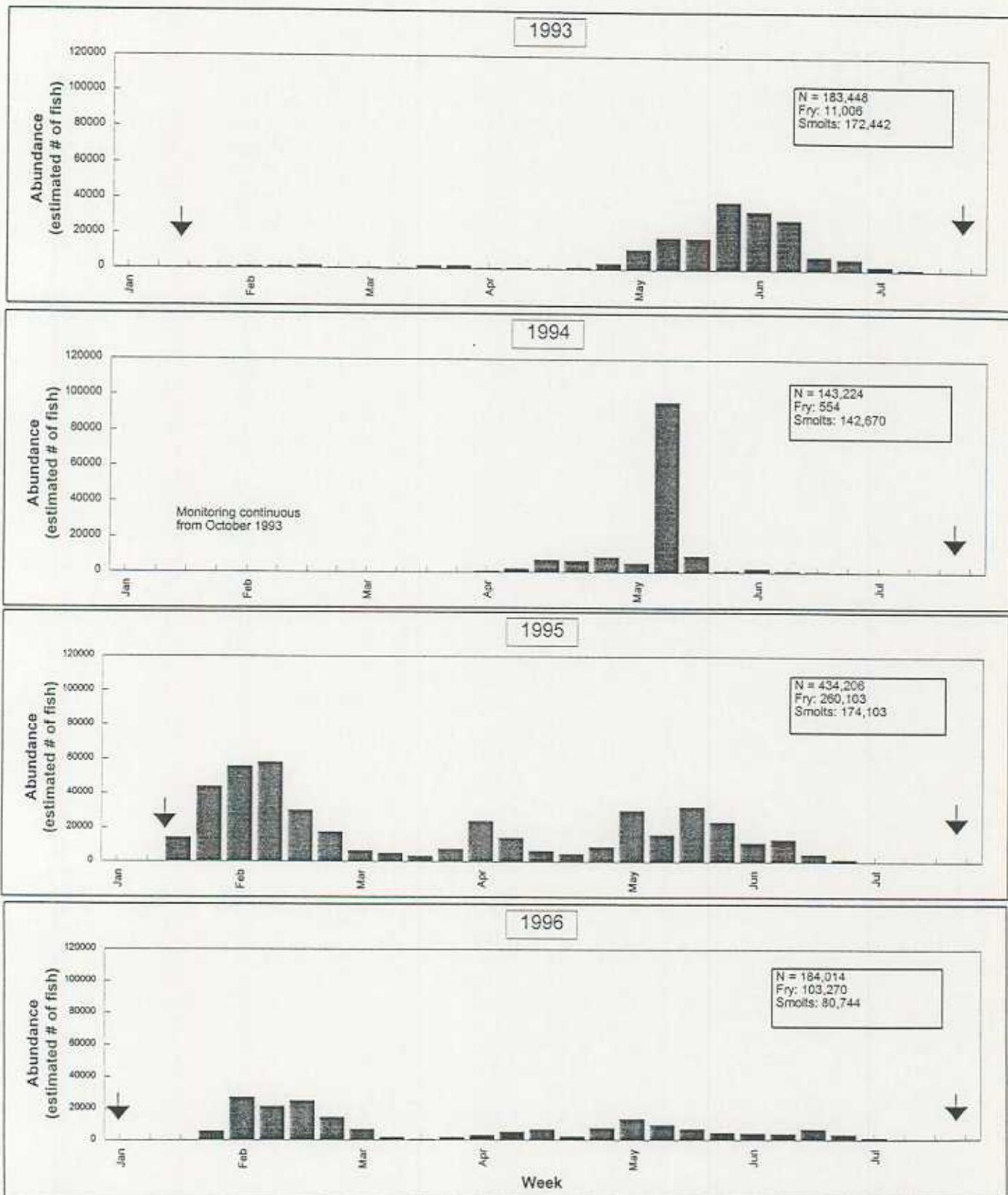


Figure 14. Weekly abundance of downstream migrant fall-run chinook salmon at Woodbridge Dam for 1993-1996. (Abundance was determined using experimentally -derived capture probabilities for rotary traps [and adding fishway trap captures in '94]). Month labels are on the middle week of each month. Arrows indicate the beginning and end of annual monitoring periods.

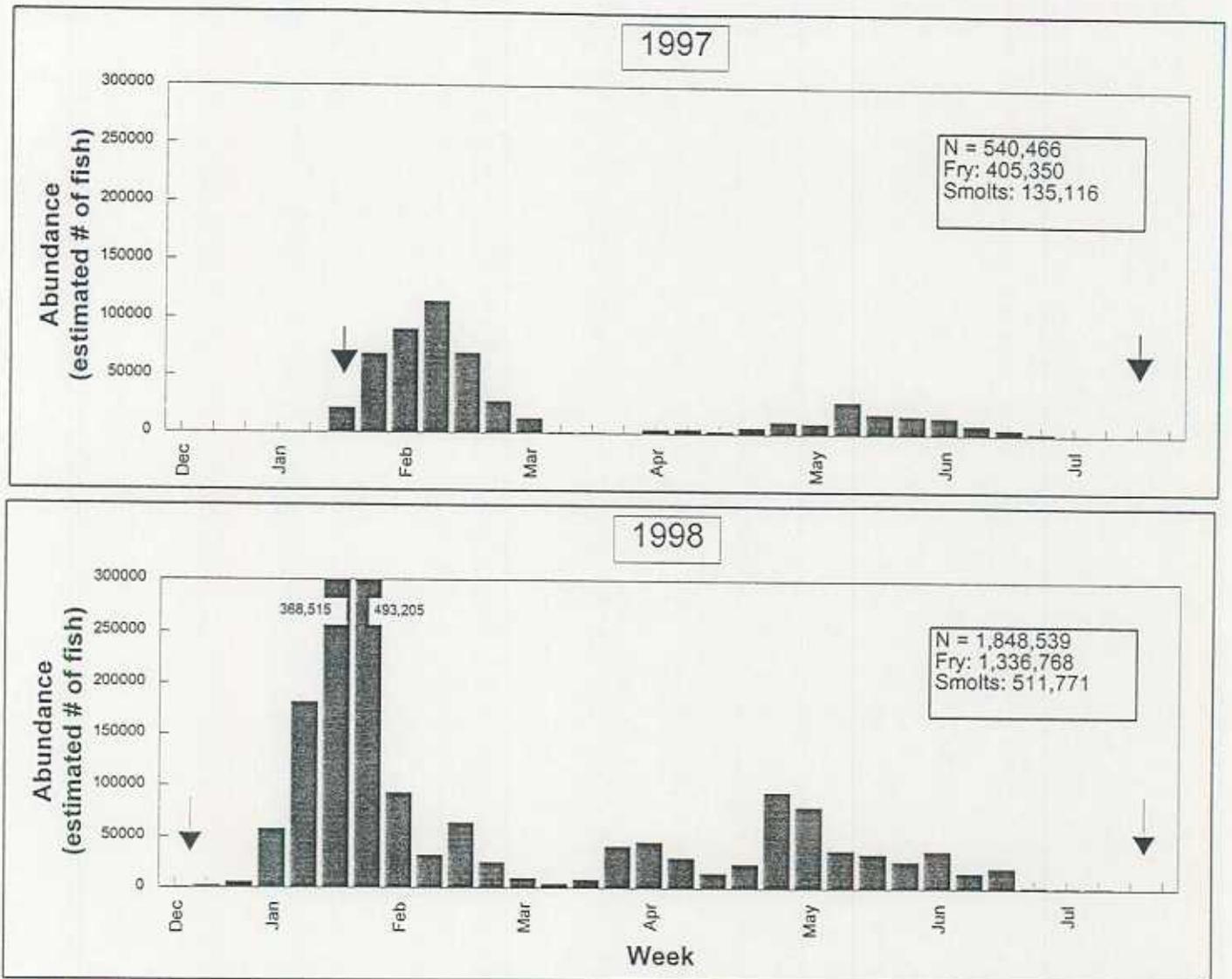


Figure 15. Weekly abundance of downstream migrant fall-run chinook salmon at Woodbridge Dam for 1997-1998. (Abundance was determined using experimentally-derived capture probabilities [and adding fishway trap captures in '97]). Month labels are on the middle week of each month. Arrows indicate the beginning and end of annual monitoring periods. Abundance values that exceed scale are presented as text.

The natural production of BY97 juvenile fall-run chinook salmon emigrating from the Mokelumne River, estimated at 1,848,539 (~1,336,768 fry and ~511,771 smolts), was the highest total production estimated since 1990. Both fry and smolt migrations exhibited large increases in 1998 compared to earlier years. While caution must be used in making direct comparisons between years because of differences in sampling periods, data are sufficient to suggest that the timing of fry and smolt emigrations is fairly consistent but the magnitude of the numbers of fry migrants varies to a greater extent than that of smolts. This phenomenon is observed elsewhere in the range of chinook salmon, such as the Big Qualicum River on Vancouver Island where numbers of emigrating fry may vary by as much as 100-fold annually but emigrating smolts by only as much as 10-fold (Lister and Walker 1966).

3.6 Assessment of Survival of Juvenile Chinook Salmon Migrating Through the Sacramento-San Joaquin Delta During the Spring of 1998.

3.6.1 MRFI Chinook Salmon

Table 3 provides the release and recovery data for tagged fish groups used for the 1998 assessment of Delta survival of salmon smolts emigrating from the Mokelumne River. Table 4 gives specific release data for all of the tag groups marked and released as part of Mokelumne River fishery assessments in 1998.

Table 3. Release and recovery information for four groups of Mokelumne River Fish Installation CWT juvenile fall-run chinook salmon captured at the Chipps Island USFWS trawling station, Spring 1998.

Tag Code	Release Date	Number of Fish Tagged	Date of First Catch	Date of Last Catch	Number of Fish Recovered	Days at Large	Minutes Sampled	Fraction of Time Sampled	Estimated Survival
06-02-32	04/21/98 Thornton	51,107	04/26/98	05/17/98	48	22	8435	0.2663	0.4395
06-02-33	04/21/98 Thornton	51,372	04/26/98	05/15/98	30	20	7695	0.2672	0.2841
06-02-34	04/28/98 Jersey Pt.	51,228	04/28/98	05/14/98	110	18	6100	0.2848	1.0544
06-02-35	04/28/98 Jersey Pt.	52,128	04/28/98	05/16/98	105	20	7635	0.2851	0.9878

The USFWS formula for calculating estimated fish survival based on recoveries of tagged fish in trawling samples collected by the USFWS near Chipps Island is:

Estimated Survival = $R / [(M) (30 \text{ feet} / 3900 \text{ feet}) (\text{Proportion of Time Sampled})]$
 where R = number of tagged fish recovered and M = number of fish tagged (Mark Pierce, USFWS, Stockton, personal communication). A calculated value of 1.0 would represent 100-percent survival.

Table 4. 1998 coded-wire tag mark and release data for Mokelumne River fall-run chinook salmon.

Code ID	Egg Lot No.	Brood Year	Release Location	Date Released		Rearing Type	Purpose	Total No. Tagged	Estimated Tag Loss and Mortality Before Release, %	No. Tagged Fish Released ¹	Quality Control Days	No./lb at Release	Avg. Length in FL, mm	Rearing Location	Stock of Release Group
				First	Last										
6-02-32*	Mixed	1997	New Hope Ldg. Mokelumne R.	4/21/98	4/21/98	Hatchery	Delta Mortality	51,522	0.8	51,107	21	72	81	MRFI	MOK97
6-02-33*	Mixed	1997	New Hope Ldg. Mokelumne R.	4/21/98	4/21/98	Hatchery	Delta Mortality	52,156	1.5	51,372	19	72	77	MRFI	MOK97
6-02-34*	Mixed	1997	Jersey Pt.-San Joaquin R.	4/28/98	4/28/98	Hatchery	Delta Mortality	52,309	2.0	51,228	26	55.5	86	MRFI	MOK97
6-02-35*	Mixed	1997	Jersey Pt.-San Joaquin R.	4/28/98	4/28/98	Hatchery	Delta Mortality	53,228	2.0	52,128	24	55.5	84	MRFI	MOK97
6-02-38**	Mixed	1997	New Hope Ldg.	5/14/98	5/28/98	Hatchery	Mitigation	52,088	2.0	51,046	12	39	101	MRFI	MOK97
6-02-39**	Mixed	1997	New Hope Ldg.	5/14/98	5/28/98	Hatchery	Mitigation	52,463	3.0	51,024	10	39	101	MRFI	MOK97
6-02-40**	Mixed	1997	San Pablo Bay	6/12/98	6/23/98	Hatchery	Enhance	52,476	3.0	51,074	22	25	115	MRFI	MOK97
6-02-41**	Mixed	1997	San Pablo Bay	6/12/98	6/23/98	Hatchery	Enhance	52,854	3.0	52,427	22	25	115	MRFI	MOK97
6-1-13-1-14	Wild	1997	Woodbridge Dam	3/01/98	4/15/98	Wild	Survival & Fishery	12,531	10.0 ³	11,278	7	182	45-59 ³	Mokelumne River	Mokelumne R.
6-1-13-1-15	Wild	1997	Woodbridge Dam	4/16/98	5/06/98	Wild	Survival & Fishery	12,585	3.3 ³	11,367	7	71	87	Mokelumne River	Mokelumne R.
6-1-13-2-01	Wild	1997	Woodbridge Dam	5/07/98	5/20/98	Wild	Survival & Fishery	14,132	8.0 ³	12,351	6	58	92	Mokelumne River	Mokelumne R.
6-1-13-2-02	Wild	1997	Woodbridge Dam	5/20/98	6/10/98	Wild	Survival & Fishery	12,252	15.0 ³	10,414	7	47	97	Mokelumne River	Mokelumne R.

Table 4. 1997 coded-wire tag mark and release data for Mokelumne River fall-run chinook salmon (continued).

Code ID	Egg Lot No.	Brood Year	Release Location	Date Released		Rearing Type	Purpose	Total No. Tagged	Estimated Tag Loss and Mortality Before Release, %	No. Tagged Fish Released ¹	Quality Control Days	No./lb at Release	Avg. Length in FL, mm	Rearing Location	Stock of Release Group
				First	Last										
6-1-13-2-03	Wild	1997	Woodbridge Dam	6/1/98	8/02/98	Wild	Survival & Fishery	4,132	15.7 ²	3,483	7	31	109	Mokelumne River	Mokelumne R.
6-02-36**	Mixed	1997	Woodbridge Dam	10/29/98	11/17/98	Hatchery	Yearling	52,588	69.9	16,661	176	5	183	MRF1	MOK97
6-02-37**	Mixed	1997	Woodbridge Dam	10/29/98	11/17/98	Hatchery	Yearling	52,155	69.6	16,660	174	5	183	MRF1	MOK97

* Paired groups were mixed, trucked, and released together, after individual tag retention and size checks.

** Paired groups reared together for 1 or more months prior to trucking and release. Tag retention checked prior to mixing.

¹ Adjusted for estimated shed tags and pre-release mortality.

² Range in average size for entire time interval over which tag code was used.

³ Based on one to three 6-7 day post-tagging holding periods.

Recovery of the tagged fish from the *test* group was somewhat greater than past years' results for fish released at New Hope Landing. Recovery of both *test* and *control* groups occurred homogeneously over about 2 two weeks after their release (chi-square for tagged sublots, 1 *df*, $P > 0.05$). More tagged fish from the *control* group than from the *test* group were recaptured in the Chipp's Island trawl (Table 3). Estimates of *relative survival*, which is the differential survival between the *test* and *control* groups, were calculated from USFWS's survival indices for the different groups (Table 3). These *relative survival* estimates ranged from 0.2694 to 0.4449, with an average of 0.3547 (95% C.I. = 0.2675 - 0.4419). Delta hydrologic conditions were characteristic of a very wet year and relatively stable during April and May when tagged fish were recovered by the trawl, and presumably in the Delta. The daily average Delta outflow ranged from about 60,000 cfs to 70,000 cfs during the period that tagged fish were being recaptured. Pumping rates at the Central Valley Project (CVP) and Contra Costa Water District diversions changed little, while the State Water Project (SWP) diversion increased during this period (Appendix F). No study fish were recovered at fish salvage facilities at either the CVP or SWP diversions.

3.6.2 Comparison of Annual Delta Survival Results for Mokelumne River Smolts

Table 5 summarizes the results of eight years of survival investigations of fall-run chinook salmon smolts emigrating from the Mokelumne River through the Delta. From 1991 through 1995, releases were made early and late in the outmigration season to examine potential seasonal differences in effects of Delta operations on smolt survival based on USFWS's Chipps Island trawl recovery survival index. Since 1996, coded wire tagged fish releases have been performed in an experimental framework that provides for a refined estimation of actual survival based on USFWS's trawls at Chipps Island.

Recoveries of coded wire tagged hatchery smolts during 1998 suggest smolt survival was relatively high compared to earlier years. The 1998 test groups released at New Hope Landing had a mean survival index of 0.36 which was the fourth highest observed since 1991. The differential survival value (0.35), which is an estimate of actual survival experienced by emigrating smolts, was the highest for this type of experiment using Mokelumne River salmon since they began in 1996.

Table 5. Mean Delta survival indices for experimental releases of coded wire tagged fall-run chinook salmon smolts reared at MRFI and released in the Delta from 1991 to 1998.

Migration Year	Stock	Experimental Release Type and Location				Differential Survival between Test and Control Groups ²
		Early Season (New Hope Landing)	Late Season (New Hope Landing)	Test Group (New Hope Landing)	Control Group (Jersey Point)	
1991	Feather R.	1.53	0.47	n/a	n/a	n/a
1992 ¹	Feather R.	0.14	0.06	n/a	n/a	n/a
1993	Feather R.	0.27	0.11	n/a	n/a	n/a
1994	Mokelumne R.	0.11	0.17	n/a	n/a	n/a
1995	Mokelumne R.	0.48	0.49	n/a	n/a	n/a
1996	Feather R.	n/a	n/a	0.27	1.77	0.15
1997	Mokelumne R.	n/a	n/a	0.14	0.57	0.26
1998	Mokelumne R.	n/a	n/a	0.36	1.02	0.35

¹ Survival index values for this year are based on release groups consisting of a single tag code.
² Differential survival value is the mean of individual ratios of test and control survival indexes.

The 1998 Mokelumne River smolt survival in the Delta was comparable to that reported for similar experiments performed with Merced River smolts (Table 6). These coded wire tagged smolts were released at the entrance of the San Joaquin River in the Delta near Mossdale and Dos Reis Park. Both of these Merced River release groups experienced similar survival relative to their control released at Jersey Point (0.30 and 0.32, respectively). A replicated experiment in the San Joaquin River using Feather River Hatchery origin smolts was performed for experimental validation purposes by USFWS; the results of which were different from that using the Merced River Hatchery origin smolts (Table 6). This suggests that use of out of basin stocks for these types of experiments may not yield representative data for the stocks of interest.

Table 6. Results of USFWS/VAMP Delta survival experimental releases of coded wire tagged fall-run chinook salmon smolts from Merced River Hatchery and Feather River Hatchery, Spring 1998.

Stock ¹	Number Released	Release Date	Release Location	Reported Survival Index	Differential Survival Compared to Jersey Point ²
MRFF	77,855	4/16/98	Mossdale, San Joaquin R.	0.5583	0.30
MRFF	77,373	4/17/98	Dos Reis, San Joaquin R.	0.5948	0.32
MRFF	60,271	4/20/98	Jersey Point	1.8400	n/a
FRH	33,989	4/23/98	Mossdale, San Joaquin R.	0.1008	0.15
FRH	48,101	4/24/98	Dos Reis, San Joaquin R.	0.1732	0.26
FRH	44,109	4/27/98	Lighthouse Marina, San Joaquin R.	0.8765	n/a
FRH	31,198	4/28/98	Jersey Point	0.6688	n/a

¹ MRFF=Merced River Hatchery; FRH=Feather River Hatchery

² Differential survival value is the ratio of test site's reported survival index to that of associated Jersey Point control release.

3.6.3 Wild Chinook Salmon Smolts Coded-Wire Tagged at Woodbridge Dam

Appendix A provides a daily record of the numbers of wild fall-run chinook salmon fry/parr and smolts captured, coded-wire tagged, and released at Woodbridge Dam. Additional relevant data are provided in Table 4. Fish were tagged from March 1 until August 2, 1998. Five microtag codes (1/2-size tags) were used during the season to tag 55,632 fish (Table 4). Approximately 8,500 of these juvenile salmon were fry/parr marked and released during March 1998.

Latent mortality ranged from 0% to 8% with 14 fish out of 282 held that died in 10 separate tests (6 to 7 days long). Tag retention efficiency ranged from 74% to 100% during these tests. In general, tag retention was 90% to 100%. Procedures were evaluated and modified as necessary when tag retention declined. Tagging reports were submitted to the CDFG in August 1998. Thirteen wild fry/parr tagged from March to early April and 20 wild smolts tagged from April to May were recaptured by the USFWS trawl at Chipps Island from April to June (USFWS unpublished data).

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ACRONYMS

Acronym/Abbreviation	Definition
CDFG	California Department of Fish and Game
cfs	cubic feet per second
cm	centimeter
CVP	Central Valley Project
CWT	coded-wire tagged
DO	dissolved oxygen
EBMUD	East Bay Municipal Utility District
FRH	Feather River Fish Hatchery
FL	fork length
K	average condition factor
L	Liter
m	meters
ml	milliliter
mm	millimeter
MRFF	Merced River Fish Facility
MRFI	Mokelumne River Fish Installation
NRS	Natural Resource Scientists, Inc.
PVC	polyvinyl chloride
QCD	quality control device
RM	river mile
SD	standard deviation
SWP	State Water Project
TBS	to be supplied
TL	total length
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VAMP	Vernalis Adaptive Management Plan
WID	Woodbridge Irrigation District
WIDD	Woodbridge Irrigation District Dam
WQ	water quality
w/w	formulation made by combination on a dry weight to dry weight ratio
YOY	young-of-year

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APPENDICES

Appendix A. Daily trapping abundance of fall chinook salmon YOY: December 15, 1997 -- August 2, 1998.

Date	Nocturnal			Diurnal			Daily Totals**			Trap Operations Data				
	Captured	Mortality	Injury	Captured	Mortality	Injury	Captured	Mortality	Injury	CWT	Number Fished	Nocturnal (Hours)	Diurnal (Hours)	Non-Diel Specific* (Hours)
12/15/97	-	-	-	0	0	0	0	0	0	0	2	19.75	6.42	6.42
12/16/97	-	-	-	-	-	-	-	-	-	-	2	-	-	19.75
12/17/97	-	-	-	-	-	-	-	-	-	-	2	-	-	23.75
12/18/97	-	-	-	-	-	-	-	-	-	-	2	-	-	26.00
12/19/97	-	-	-	-	-	-	-	-	-	-	2	-	-	23.50
12/20/97	-	-	-	-	-	-	-	-	-	-	2	-	-	24.00
12/21/97	-	-	-	-	-	-	-	-	-	-	2	-	-	24.50
12/22/97	-	-	-	-	-	-	-	-	-	-	2	-	-	23.25
12/23/97	-	-	-	-	-	-	-	-	-	-	2	-	-	23.83
12/24/97	-	-	-	-	-	-	-	-	-	-	2	-	-	22.08
12/25/97	-	-	-	-	-	-	-	-	-	-	2	-	-	26.08
12/26/97	-	-	-	-	-	-	-	-	-	-	2	-	-	22.58
12/27/97	-	-	-	-	-	-	-	-	-	-	2	-	-	23.50
12/28/97	-	-	-	-	-	-	-	-	-	-	2	-	-	25.17
12/29/97	-	-	-	-	-	-	-	-	-	-	2	-	-	24.83
12/30/97	-	-	-	-	-	-	-	-	-	-	2	-	-	24.25
12/31/97	-	-	-	-	-	-	-	-	-	-	2	-	-	45.67
01/01/98	-	-	-	-	-	-	-	-	-	-	2	-	-	24.75
01/02/98	-	-	-	-	-	-	-	-	-	-	2	-	-	23.92
01/03/98	-	-	-	-	-	-	-	-	-	-	2	-	-	23.25
01/04/98	-	-	-	-	-	-	-	-	-	-	2	-	-	23.67
01/05/98	-	-	-	-	-	-	-	-	-	-	2	-	-	26.00
01/06/98	-	-	-	-	-	-	-	-	-	-	2	-	-	21.67
01/07/98	-	-	-	-	-	-	-	-	-	-	2	-	-	23.79
01/08/98	-	-	-	-	-	-	-	-	-	-	2	-	-	25.33
01/09/98	-	-	-	-	-	-	-	-	-	-	2	-	-	25.46
01/10/98	-	-	-	-	-	-	-	-	-	-	2	-	-	23.83
01/11/98	-	-	-	-	-	-	-	-	-	-	2	-	-	22.04
01/12/98	-	-	-	-	-	-	-	-	-	-	2	-	-	22.92
01/13/98	-	-	-	72	0	0	0	0	0	0	2	-	5.67	-
01/14/98	1017	3	0	32	1	0	0	0	0	0	2	18.50	5.58	-
01/15/98	463	3	1	32	0	0	0	0	0	0	2	18.50	5.25	-
01/16/98	750	11	0	0	0	0	0	0	0	0	2	19.75	-	-
01/17/98	-	-	-	-	-	-	-	-	-	-	2	-	-	22.75
01/18/98	-	-	-	-	-	-	-	-	-	-	2	-	-	23.92
01/19/98	-	-	-	58	0	0	0	0	0	0	2	-	4.75	-
01/20/98	3896	2	0	37	0	0	0	0	0	0	2	17.67	6.83	-
01/21/98	1107	4	0	22	0	0	0	0	0	0	2	16.75	7.25	-

Appendix A. Daily trapping abundance of fall chinook salmon YOY: December 15, 1997 -- August 2, 1998.

Date	Nocturnal			Diurnal			Daily Totals**				Trap Operations Data			
	Captured	Mortality	Injury	Captured	Mortality	Injury	Captured	Mortality	Injury	CWT	Number Fished	Nocturnal (Hours)	Diurnal (Hours)	Non-Diel Specific (Hours)
01/22/98	875	88	0	58	0	0	933	88	0	0	2	17.00	6.83	
01/23/98	1223	5	1	56	0	0	1279	5	1	0	2	17.08	6.42	
01/24/98	2080	27	0	104	3	0	2184	30	0	0	2	17.96	5.50	
01/25/98	--	--	--	--	--	--	2786	22	0	0	2			23.21
01/26/98	--	--	--	104	3	0	2083	260	0	0	2		5.50	25.00
01/27/98	3353	17	0	168	1	0	3521	18	0	0	2	19.25	5.50	
01/28/98	3452	16	0	234	2	0	3686	18	0	0	2	17.58	5.67	
01/29/98	3263	8	0	104	1	0	3367	9	0	0	2	18.50	5.50	
01/30/98	6929	10	0	98	0	0	6927	10	0	0	2	19.50	4.17	
01/31/98	5319	16	0	0	0	0	5319	16	0	0	2	19.83		
02/01/98	--	--	--	--	--	--	1969	3	0	0	2			24.00
02/02/98	--	--	--	17	0	0	1701	4	0	0	2		5.33	22.92
02/03/98	2183	6	1	900	2	0	2983	8	1	0	2	18.17	6.33	
02/04/98	--	--	--	--	--	--	8530	1678	0	0	2			24.67
02/05/98	1176	85	0	112	2	0	1268	87	0	0	2	17.33	6.25	
02/06/98	--	--	--	--	--	--	--	--	--	--	2			
02/07/98	852	2	0	0	0	0	852	2	0	0	2	19.67		
02/08/98	--	--	--	--	--	--	304	1	1	0	2			23.83
02/09/98	--	--	--	29	0	0	331	1	0	0	2		8.00	23.00
02/10/98	988	3	0	41	0	0	1029	3	0	0	2	16.33	6.50	
02/11/98	423	1	0	25	0	0	448	1	0	0	2	17.50	6.50	
02/12/98	146	0	0	0	0	0	146	0	0	0	2	17.33		
02/13/98	--	--	--	8	0	0	138	1	0	0	2		6.17	24.33
02/14/98	97	1	0	13	0	0	110	1	0	0	2	17.83	6.33	
02/15/98	147	4	0	3	0	0	150	4	0	0	2	18.67	4.75	
02/16/98	35	1	0	6	0	0	41	1	0	0	2	18.25	6.00	
02/17/98	49	2	0	12	0	0	61	2	0	0	2	15.50	8.50	
02/18/98	203	6	1	12	0	0	215	6	1	0	2	17.79	7.21	
02/19/98	81	0	1	7	0	0	88	0	1	0	2	16.67	6.58	
02/20/98	92	2	0	13	0	0	105	2	0	0	2	18.08	6.33	
02/21/98	102	2	0	5	0	0	107	2	0	0	2	17.08	7.00	
02/22/98	181	3	0	13	0	0	194	3	0	0	2	17.00	7.00	
02/23/98	99	2	1	6	0	0	105	2	1	0	2	16.67	6.08	
02/24/98	222	2	0	30	0	0	252	2	0	0	2	18.50	6.75	
02/25/98	155	1	0	20	0	0	175	1	0	0	2	17.00	6.67	
02/26/98	227	0	0	12	1	0	239	1	0	0	2	17.75	6.83	
02/27/98	341	3	0	15	0	0	356	3	0	0	2	17.17	6.00	
02/28/98	254	4	0	20	1	0	274	5	0	0	2	18.00	6.25	

Appendix A. Daily trapping abundance of fall chinook salmon YOY: December 15, 1997 -- August 2, 1998.

Date	Nocturnal				Diurnal				Daily Totals**				Trap Operations Data			
	Captured	Mortality	Injury	CWT	Captured	Mortality	Injury	CWT	Captured	Mortality	Injury	CWT	Number Fished	Nocturnal (Hours)	Diurnal (Hours)	Non-Diel Specific (Hours)
03/01/98	212	4	1	0	19	0	0	2	231	4	1	2	2	17.25	7.00	
03/02/98	90	3	0	8	19	0	0	0	109	3	0	8	2	17.33	6.42	
03/03/98	83	0	0	4	5	0	0	0	85	0	0	4	2	16.75	7.50	
03/04/98	56	4	3	2	4	0	0	0	60	4	3	2	2	17.25	7.00	
03/05/98	89	0	0	14	2	0	0	0	91	0	0	14	2	17.08	7.00	
03/06/98	69	3	1	7	1	0	0	0	70	3	1	7	2	16.87	7.00	
03/07/98	156	3	0	11	7	0	0	2	163	3	0	13	2	17.25	7.00	
03/08/98	46	0	0	0	1	0	0	0	47	0	0	0	2	16.75	6.50	
03/09/98	40	1	2	5	4	0	0	0	44	1	2	5	2	17.71	6.46	
03/10/98	44	0	0	7	9	0	0	2	53	0	0	9	2	17.04	7.37	
03/11/98	34	1	0	14	2	0	0	0	36	1	0	14	2	16.67	7.25	
03/12/98	38	1	1	15	1	0	0	0	39	1	1	15	2	17.25	6.75	
03/13/98	28	0	0	17	3	0	0	0	31	0	0	17	2	17.25	6.50	
03/14/98	42	0	1	15	0	0	0	0	42	0	1	15	2	17.75	6.00	
03/15/98	-	-	-	-	-	-	-	-	0	0	0	0	2			
03/16/98	-	-	-	-	5	0	0	5	61	1	0	57	2			41.58
03/17/98	32	0	0	25	2	0	0	0	34	0	0	25	2	17.92	7.25	
03/18/98	28	0	0	21	0	0	0	0	28	0	0	21	2	16.50	7.50	
03/19/98	11	0	0	4	1	0	0	0	12	0	0	4	2	16.50	6.75	
03/20/98	54	0	1	49	10	3	0	6	64	3	1	55	2	17.00	7.50	
03/21/98	40	0	0	40	6	1	0	5	46	1	0	45	2	16.75	6.25	
03/22/98	34	2	0	30	1	0	0	1	35	2	0	31	2	17.25	7.25	
03/23/98	17	2	0	15	1	0	0	1	18	2	0	16	2	17.50	6.75	
03/24/98	24	3	0	20	3	0	0	2	27	3	0	22	2	17.00	6.17	
03/25/98	26	0	0	26	7	0	0	7	33	0	0	33	2	17.67	6.67	
03/26/98	41	9	0	30	36	0	0	35	77	9	0	65	2	17.42	6.33	
03/27/98	182	22	0	156	30	0	0	18	212	22	0	174	2	17.75	6.50	
03/28/98	370	81	0	280	7	2	0	5	377	83	0	285	2	17.50	6.50	
03/29/98	210	5	0	203	36	1	0	22	246	6	0	225	2	17.83	5.92	
03/30/98	497	13	0	484	51	4	0	46	548	17	0	530	2	18.08	6.67	
03/31/98	1060	6	0	1052	115	1	0	113	1175	7	0	1165	2	17.00	6.50	
04/01/98	919	14	0	901	24	0	0	24	943	14	0	925	2	17.67	7.33	
04/02/98	508	3	0	503	14	0	0	13	522	3	0	516	2	17.00	6.00	
04/03/98	282	1	0	278	37	0	0	37	319	1	0	315	2	17.50	6.50	
04/04/98	602	5	1	594	39	0	0	39	641	5	1	633	2	17.50	6.50	
04/05/98	579	128	0	448	51	1	0	50	630	129	0	498	2	17.50	6.50	
04/06/98	522	4	1	516	27	0	0	27	549	4	1	543	2	17.25	6.75	
04/07/98	762	5	0	746	113	0	0	113	875	5	0	859	2	17.50	6.00	

Appendix A. Daily trapping abundance of fall chinook salmon YOY: December 15, 1997 -- August 2, 1998.

Date	Nocturnal			Diurnal			Daily Totals**				Trap Operations Data					
	Captured	Mortality	Injury	CWT	Captured	Mortality	Injury	CWT	Captured	Mortality	Injury	CWT	Number Fished	Nocturnal (Hours)	Diurnal (Hours)	Non-Diel Specific* (Hours)
04/08/98	1263	6	2	1252	142	1	0	0	1405	7	2	1252	2	17.75	6.50	
04/09/98	491	5	0	486	46	0	0	46	537	5	0	532	2	18.00	6.50	
04/10/98	572	3	0	568	65	0	0	65	837	3	0	633	2	17.33	6.33	
04/11/98	621	5	0	614	93	0	0	93	714	5	0	707	2	17.54	6.79	
04/12/98	660	8	0	300	91	0	0	91	751	8	0	391	2	17.50	6.00	
04/13/98	532	7	0	494	35	0	0	35	567	7	0	529	2	17.75	7.00	
04/14/98	448	4	0	381	131	0	0	131	577	4	0	512	2	16.75	7.00	
04/15/98	812	3	0	804	21	0	0	0	833	3	0	804	2	16.83	7.42	
04/16/98	420	71	0	344	61	9	0	52	481	80	0	396	2	17.50	6.25	
04/17/98	687	177	1	499	43	26	0	17	730	203	1	516	2	17.75	7.00	
04/18/98	245	19	1	218	7	2	0	5	252	21	1	223	2	16.83	5.83	
04/19/98	227	16	0	209	4	0	0	4	231	16	0	213	2	17.83	6.00	
04/20/98	108	14	3	93	4	4	0	0	112	18	3	93	2	18.75	5.75	
04/21/98	111	17	0	92	54	13	0	41	165	30	0	133	2	17.71	6.29	
04/22/98	177	0	1	175	10	0	0	9	187	0	1	184	2	17.00	7.00	
04/23/98	194	27	0	160	13	1	0	12	207	28	0	172	2	18.00	6.50	
04/24/98	268	6	1	258	80	1	0	79	346	7	1	337	2	16.75	6.92	
04/25/98	512	3	2	508	111	1	0	110	623	4	2	618	2	17.50	6.33	
04/26/98	161	22	2	136	20	0	0	19	181	22	2	155	2	17.25	6.75	
04/27/98	148	6	0	138	6	0	0	6	154	6	0	144	2	17.75	7.00	
04/28/98	32	20	1	12	9	1	0	8	41	21	1	20	2	16.75	6.25	
04/29/98	210	15	0	192	19	3	0	16	229	18	0	208	2	17.75	6.75	
04/30/98	357	24	0	316	49	1	0	46	406	25	0	362	2	17.00	6.75	
05/01/98	440	35	1	403	34	0	0	34	474	35	1	437	2	17.50	6.67	
05/02/98	534	14	0	501	85	1	0	83	619	15	0	584	2	17.58	6.00	
05/03/98	861	55	3	755	81	3	0	78	942	58	3	833	2	17.75	6.50	
05/04/98	936	106	0	767	162	0	0	157	1098	106	0	924	2	17.50	7.12	
05/05/98	1354	60	0	1253	145	5	0	140	1499	65	0	1393	2	17.13	6.25	
05/06/98	2225	13	0	2206	476	5	0	470	2701	18	0	2676	2	17.00	7.00	
05/07/98	3140	27	1	2338	81	1	0	0	3221	28	1	2338	2	17.83	6.17	
05/08/98	1158	28	2	1113	65	2	0	63	1223	30	2	1176	2	17.33	6.83	
05/09/98	1045	10	1	1019	118	1	0	117	1183	11	1	1136	2	17.33	6.50	
05/10/98	499	160	2	287	58	0	0	0	557	160	2	287	2	18.25	5.75	
05/11/98	2308	61	0	2179	203	3	0	199	2509	64	0	2376	2	17.33	6.75	
05/12/98	1166	15	1	1137	121	2	0	0	1287	17	1	1137	2	17.42	6.50	
05/13/98	1141	10	1	1051	127	1	0	126	1268	11	1	1177	2	17.33	7.00	
05/14/98	421	27	1	387	366	8	0	357	787	35	1	744	2	17.50	6.33	
05/15/98	1588	80	0	1444	196	9	0	181	1764	89	0	1625	2	17.33	4.25	

Appendix A. Daily trapping abundance of fall chinook salmon YOY: December 15, 1997 -- August 2, 1998.

Date	Nocturnal			Diurnal			Daily Totals**					Trap Operations Data		
	Captured	Mortality	Injury	Captured	Mortality	Injury	Captured	Mortality	Injury	CWT	Number Fished	Nocturnal (Hours)	Diurnal (Hours)	Non-Diel Specific (Hours)
05/16/98	1564	2	0	260	5	0	1824	7	0	1813	2	19.75	7.33	
05/17/98	400	26	3	96	2	0	496	28	3	464	2	17.17	6.17	
05/18/98	969	126	1	175	7	0	1144	133	1	952	2	17.50	7.33	
05/19/98	219	3	1	240	0	0	459	3	1	453	2	16.50	6.50	
05/20/98	757	2	0	195	0	0	952	2	0	949	2	17.00	7.00	
05/21/98	595	35	5	75	1	0	670	36	5	630	2	18.42	6.58	
05/22/98	383	2	0	122	5	0	505	7	0	489	2	17.25	6.25	
05/23/98	440	5	0	80	3	0	520	8	0	510	2	17.17	6.93	
05/24/98	383	4	8	128	1	0	511	5	8	504	2	16.67	7.08	
05/25/98	393	12	0	97	2	1	490	14	1	467	2	17.42	6.83	
05/26/98	376	7	12	34	0	0	410	7	12	401	2	17.00	6.67	
05/27/98	204	5	1	41	1	0	245	6	1	235	2	18.71	4.86	
05/28/98	587	15	7	44	1	0	631	16	7	604	2	17.75	6.67	
05/29/98	756	19	15	258	2	0	1012	21	15	969	2	17.00	7.50	
05/30/98	426	1	1	218	9	0	644	10	1	630	2	16.50	7.50	
05/31/98	703	51	0	132	3	3	835	54	3	756	2	17.17	7.00	
06/01/98	564	36	9	157	0	4	721	36	13	679	2	17.00	7.25	
06/02/98														
06/03/98	177	0	3				177	0	3	176	2	15.75		
06/04/98	132	1	0	143	0	0	275	1	0	273	2	18.00	7.00	
06/05/98	777	109	0	159	2	0	936	111	0	801	2	18.33	4.92	
06/06/98	562	19	13	163	1	3	725	20	16	667	2	17.92	6.50	
06/07/98	457	29	10	69	0	0	526	29	10	457	2	17.33	6.67	
06/08/98	419	14	7	240	0	0	659	14	7	640	2	16.83	7.50	
06/09/98	747	18	6	255	14	0	1002	32	6	944	2	17.17	6.33	
06/10/98	707	3	1	129	0	0	836	3	1	828	2	17.00	7.00	
06/11/98	512	113	10	106	1	1	618	114	11	489	2	17.83	6.42	
06/12/98	222	19	8	299	1	0	521	20	8	488	2	17.42	6.33	
06/13/98	564	69	1	183	1	5	757	70	6	670	2	17.25	7.08	
06/14/98	379	27	11	71	0	0	450	27	11	406	2	17.67	6.17	
06/15/98	270	73	2	161	0	5	431	73	7	355	2	17.33	6.67	
06/16/98	349	65	8	99	0	3	448	65	11	375	2	17.08	7.00	
06/17/98	223	21	3	68	1	0	291	22	3	259	2	17.08	7.17	
06/18/98	203	8	0	45	0	0	248	8	0	238	2	17.50	6.67	
06/19/98	153	3	1	134	1	1	287	4	2	282	2	16.50	7.33	
06/20/98	231	6	2	62	0	0	293	6	2	283	2	16.58	7.17	
06/21/98	22	1	1	25	0	0	22	1	1	21	2	17.25		
06/22/98	75	1	2				100	1	2	91	1	17.25	6.67	

Appendix A. Daily trapping abundance of fall chinook salmon YOY: December 15, 1997 -- August 2, 1998.

Date	Nocturnal			Diurnal			Daily Totals**			Trap Operations Data						
	Captured	Mortality	Injury	CWT	Captured	Mortality	Injury	CWT	Captured	Mortality	Injury	CWT	Number Fished	Nocturnal (Hours)	Diurnal (Hours)	Non-Diel Specific (Hours)
06/23/98	52	2	2	49	22	12	0	10	74	14	2	59	1	18.00	6.50	
06/24/98	6	1	0	5	3	0	1	3	9	1	1	8	1	18.83	7.00	
06/25/98	11	0	0	11	5	0	0	5	16	0	0	16	1	16.75	6.50	
06/26/98	6	0	1	6	4	0	0	4	10	0	1	10	1	17.50	7.00	
06/27/98	7	0	0	7	2	0	0	2	9	0	0	9	2	17.75	5.37	
06/28/98	1	0	0	1	5	0	0	5	6	0	0	6	2	17.50	6.50	
06/29/98	2	0	0	1	0	0	0	0	2	0	0	1	2	17.67	6.50	
06/30/98	4	1	0	3	2	0	0	2	6	1	0	5	2	17.33	7.00	
07/01/98	11	0	1	11	0	0	0	0	11	0	1	11	2	17.25	6.75	
07/02/98	7	0	0	7	0	0	0	0	7	0	0	7	2	17.17	6.50	
07/03/98	5	0	0	5	1	0	0	1	6	0	0	6	2	17.17	6.83	
07/04/98	0	0	0	0	3	0	0	3	3	0	0	3	2	17.50	7.00	
07/05/98	0	0	0	0	1	0	0	1	1	0	0	1	2	17.33	6.00	
07/06/98	2	0	0	1	0	0	0	0	2	0	0	1	2	17.83	5.17	
07/07/98	6	0	1	6	0	0	0	0	6	0	1	6	2	18.17	7.21	
07/08/98	4	0	0	4	1	0	0	1	5	0	0	5	2	17.17	6.58	
07/09/98	4	1	0	3	1	0	0	1	4	1	0	3	2	17.33		
07/10/98	2	0	1	2	1	0	0	1	3	0	1	3	2	15.08	7.17	
07/11/98	1	0	0	1	1	0	0	1	1	0	0	1	2	17.50		
07/12/98	0	0	0	0	1	0	0	1	1	0	0	1	2	14.58	7.25	
07/13/98	1	0	0	1	1	0	0	0	2	0	0	1	2	16.75	7.17	
07/14/98	1	0	0	1	0	0	0	0	1	0	0	1	2	16.75	4.92	
07/15/98	2	0	0	2	0	0	0	0	2	0	0	2	2	17.17	6.83	
07/16/98	3	0	0	3	0	0	0	0	3	0	0	3	2	16.67	6.67	
07/17/98	0	0	0	0	0	0	0	0	0	0	0	0	2	17.00	7.17	
07/18/98	0	0	0	0	0	0	0	0	0	0	0	0	2	15.50	8.00	
07/19/98	0	0	0	0	0	0	0	0	0	0	0	0	2	17.42	6.33	
07/20/98	0	0	0	0	0	0	0	0	0	0	0	0	2	17.50	7.08	
07/21/98	0	0	0	0	0	0	0	0	0	0	0	0	2	17.17	6.50	
07/22/98	0	0	0	0	0	0	0	0	0	0	0	0	2	17.50	6.67	
07/23/98	2	0	0	2	0	0	0	0	2	0	0	2	2	17.17	7.17	
07/24/98	0	0	0	0	0	0	0	0	0	0	0	0	2	17.17	6.33	
07/25/98	0	0	0	0	0	0	0	0	0	0	0	0	2	16.00	9.17	
07/26/98	0	0	0	0	0	0	0	0	0	0	0	0	2	16.87	6.63	
07/27/98	0	0	0	0	0	0	0	0	0	0	0	0	2	16.83	6.83	
07/28/98	2	1	0	1	0	0	0	0	2	1	0	1	2	17.17	6.75	
07/29/98	0	0	0	0	0	0	0	0	0	0	0	0	2	17.25	6.83	
07/30/98	0	0	0	0	0	0	0	0	0	0	0	0	2	17.33	6.33	

Appendix A. Daily trapping abundance of fall chinook salmon YOY: December 15, 1997 -- August 2, 1998.

Date	Nocturnal			Diurnal			Daily Totals**			Trap Operations Data				
	Captured	Mortality	Injury	Captured	Mortality	Injury	Captured	Mortality	Injury	CWT	Number Fished	Nocturnal (Hours)	Diurnal (Hours)	Non-Diel Specific (Hours)
07/31/98	0	0	0	3	0	0	3	0	0	1	2	17.50	7.00	
08/01/98	1	0	0	0	0	0	1	0	0	1	2	16.58	7.17	
08/02/98	1	0	0	0	0	0	1	0	0	1	2	16.92	6.83	
TOTALS	94606	2798	203	11349	210	27	126838	5100	233	55569				

* Trap checked once daily or every other day without regard to diel (day/night) intervals.

** Daily totals include fish captured during nocturnal, diurnal, and non-diel specific periods. Therefore, sum of nocturnal and diurnal counts will not always equal daily total if non-diel specific captures occur.

Appendix B. Daily trapping abundance of juvenile steelhead: December 15, 1997 -- August 2, 1998.

Date	Nocturnal		Diurnal		YOY	Age 1+ Ad-clip	YOY	Age 1+ Ad-clip	Daily Totals**		YOY	Age 1+ Ad-clip	Number Fished	Trap Operations Data		
	YOY	Age 1+ Ad-clip	YOY	Age 1+ Ad-clip					Age 1+	Age 1+ Ad-clip				Nocturnal (Hours)	Diurnal (Hours)	Non-Diet Specific* (Hours)
12/15/97													2	19.75	6.42	6.42
12/16/97													2			19.75
12/17/97													2			23.75
12/18/97													2			26.00
12/19/97													2			23.50
12/20/97													2			24.00
12/21/97													2			24.50
12/22/97													2			23.25
12/23/97													2			23.83
12/24/97													2			22.08
12/25/97													2			26.08
12/26/97													2			22.58
12/27/97													2			23.50
12/28/97													2			25.17
12/29/97													2			24.83
12/30/97													2			24.25
12/31/97													2			
01/01/98													2			45.67
01/02/98													2			24.75
01/03/98													2			23.92
01/04/98													2			23.25
01/05/98													2			23.67
01/06/98													2			26.00
01/07/98													2			21.67
01/08/98													2			23.79
01/09/98													2			25.33
01/10/98													2			25.46
01/11/98													2			23.83
01/12/98													2			22.04
01/13/98													2			22.92
01/14/98													2			
01/15/98													2			5.67
01/16/98													2			5.58
01/17/98													2			5.25
01/18/98													2			
01/19/98													2			22.75
01/20/98													2			23.92
01/21/98													2			25.83
01/22/98													2			
01/23/98													2			4.75
01/24/98													2			6.83
01/25/98													2			7.25
01/26/98													2			17.00
01/27/98													2			6.83
													2			17.08
													2			6.42
													2			5.50
													2			23.21
													2			25.00
													2			
													2			19.25
													2			5.50
													2			5.50

Appendix B. Daily trapping abundance of juvenile steelhead: December 15, 1997 -- August 2, 1998.

Date	Nocturnal		Diurnal		Daily Totals**		Trap Operations Data			
	YOY	Age 1+ Ad-clip	YOY	Age 1+ Ad-clip	Age 1+	Age 1+ Ad-clip	Number Fished	Nocturnal (Hours)	Diurnal (Hours)	Non-Diel Specific* (Hours)
01/28/98	0	0	0	0	0	0	2	17.58	5.67	
01/29/98	0	0	0	0	0	0	2	18.50	5.50	
01/30/98	0	1	0	0	1	1	2	19.50	4.17	
01/31/98	0	0	0	0	0	0	2	19.83		
02/01/98	-	-	-	-	0	0	2			24.00
02/02/98	-	-	0	0	0	0	2		5.33	22.92
02/03/98	0	0	0	0	0	0	2	18.17	6.33	
02/04/98	-	-	-	-	0	0	2			
02/05/98	0	0	0	0	0	0	2	17.33	6.25	24.67
02/06/98										
02/07/98	0	0	0	0	0	0	2	19.67		
02/08/98	-	-	-	-	0	0	2			
02/09/98	-	-	0	0	0	0	2			
02/10/98	0	1	0	0	1	1	2	16.33	8.00	23.83
02/11/98	0	0	0	0	0	0	2	17.50	6.50	23.00
02/12/98	0	0	0	0	0	0	2	17.33	6.50	
02/13/98	-	-	0	0	0	0	2			
02/14/98	0	0	0	0	0	0	2	17.83	6.17	24.33
02/15/98	0	0	0	0	0	0	2	18.67	6.33	
02/16/98	0	0	0	0	0	0	2	18.25	4.75	
02/17/98	0	0	0	0	0	0	2	15.50	6.00	
02/18/98	0	0	0	0	0	0	2	17.79	7.21	
02/19/98	0	0	0	0	0	0	2	16.67	6.58	
02/20/98	0	0	0	0	0	0	2	18.08	6.33	
02/21/98	0	0	0	0	0	0	2	17.08	7.00	
02/22/98	0	0	0	0	0	0	2	17.00	7.00	
02/23/98	0	0	0	0	0	0	2	16.67	6.08	
02/24/98	0	0	0	0	0	0	2	18.50	6.75	
02/25/98	0	0	0	0	0	0	2	17.00	6.67	
02/26/98	0	0	0	0	0	0	2	17.75	6.83	
02/27/98	0	1	0	0	1	1	2	17.17	6.00	
02/28/98	0	1	0	0	1	1	2	18.00	6.25	
03/01/98	0	0	0	0	0	0	2	17.25	7.00	
03/02/98	0	0	0	0	0	0	2	17.33	6.42	
03/03/98	0	0	0	0	0	0	2	16.75	7.50	
03/04/98	0	0	0	0	0	0	2	17.25	7.00	
03/05/98	0	1	0	0	1	1	2	17.08	7.00	
03/06/98	0	1	0	0	1	1	2	16.67	7.00	
03/07/98	0	1	0	0	1	1	2	17.25	7.00	
03/08/98	0	0	0	0	0	0	2	16.75	6.50	
03/09/98	0	1	0	0	1	1	2	17.71	6.46	
03/10/98	0	0	0	0	0	0	2	17.04	7.37	
03/11/98	0	0	0	0	0	0	2	16.67	7.25	
03/12/98	0	0	0	0	0	0	2	17.25	6.75	

Appendix B. Daily trapping abundance of juvenile steelhead: December 15, 1997 -- August 2, 1998.

Date	Nocturnal		Diurnal		Daily Totals**		Trap Operations Data				
	YOY	Age 1+	YOY	Age 1+	YOY	Age 1+	Age 1+ Ad-clip	Number Fished	Nocturnal (Hours)	Diurnal (Hours)	Non-Diel Specific* (Hours)
		Age 1+ Ad-clip		Age 1+ Ad-clip		Age 1+ Ad-clip					
03/13/98	0	0	0	0	0	0	0	2	17.25	6.50	
03/14/98	0	0	0	0	0	0	0	2	17.75	6.00	
03/15/98	--	--	--	--	--	--	--	2			
03/16/98	0	0	0	0	0	0	0	2			
03/17/98	0	0	0	0	0	0	0	2	17.92	7.25	41.58
03/18/98	1	0	0	0	0	0	0	2	16.50	7.50	
03/19/98	0	0	0	0	1	0	0	2	16.50	6.75	
03/20/98	0	0	0	0	0	0	0	2	17.00	7.50	
03/21/98	0	0	0	0	0	0	0	2	16.75	6.25	
03/22/98	0	0	0	0	0	0	0	2	17.25	7.25	
03/23/98	0	0	0	0	0	0	0	2	17.50	6.75	
03/24/98	0	1	0	0	0	0	1	2	17.00	6.17	
03/25/98	0	0	0	0	0	0	0	2	17.67	6.67	
03/26/98	0	2	0	1	0	0	1	2	17.42	6.33	
03/27/98	0	1	0	0	0	0	0	2	17.75	6.50	
03/28/98	0	0	0	0	0	0	0	2	17.50	6.50	
03/29/98	0	0	0	0	0	0	0	2	17.83	5.92	
03/30/98	0	0	0	0	0	0	0	2	18.08	6.67	
03/31/98	0	1	0	0	0	0	0	2	17.00	6.50	
04/01/98	0	0	0	0	0	0	0	2	17.67	7.33	
04/02/98	1	0	0	0	0	0	0	2	17.00	6.00	
04/03/98	0	0	0	0	0	0	0	2	17.50	6.50	
04/04/98	0	1	0	0	0	0	0	2	17.50	6.50	
04/05/98	0	1	0	0	0	0	0	2	17.50	6.50	
04/06/98	0	0	0	0	0	0	0	2	17.25	6.75	
04/07/98	0	1	0	0	0	0	0	2	17.50	6.00	
04/08/98	0	1	0	0	0	0	0	2	17.75	6.50	
04/09/98	0	1	0	0	0	0	0	2	18.00	6.50	
04/10/98	0	1	0	0	0	0	0	2	17.33	6.33	
04/11/98	0	0	0	0	0	0	0	2	17.54	6.79	
04/12/98	0	0	0	0	0	0	0	2	17.50	6.00	
04/13/98	0	1	0	0	0	0	0	2	17.75	7.00	
04/14/98	0	0	0	0	0	0	0	2	16.75	7.00	
04/15/98	0	0	0	0	0	0	0	2	16.83	7.42	
04/16/98	0	0	0	0	0	0	0	2	17.50	6.25	
04/17/98	0	1	0	0	1	0	0	2	17.75	7.00	
04/18/98	2	0	0	0	0	0	0	2	16.83	5.83	
04/19/98	0	2	0	0	2	0	0	2	18.75	5.75	
04/20/98	0	0	0	0	0	0	0	2	17.71	6.29	
04/21/98	0	1	0	0	0	0	0	2	17.00	7.00	
04/22/98	0	0	0	0	0	0	0	2	18.00	6.50	
04/23/98	0	1	0	0	0	0	0	2	16.75	6.92	
04/24/98	0	0	0	0	0	0	0	2	17.50	6.33	
04/25/98	0	0	0	0	0	0	0	2			

Appendix B. Daily trapping abundance of juvenile steelhead: December 15, 1997 -- August 2, 1998.

Date	Nocturnal			Diurnal			Daily Totals**			Trap Operations Data				
	YOY	Age 1+		YOY	Age 1+		YOY	Age 1+		Age 1+ Ad-clip	Number Fished	Nocturnal	Diurnal	Non-Dial Specific*
		Age 1+	Ad-clip		Age 1+	Ad-clip		Age 1+	Ad-clip			(Hours)	(Hours)	(Hours)
04/26/98	0	0	0	0	0	0	0	0	0	0	2	17.25	6.75	
04/27/98	0	0	0	0	0	0	0	0	0	0	2	17.75	7.00	
04/28/98	0	0	0	0	0	0	0	0	0	0	2	16.75	6.25	
04/29/98	0	0	0	0	0	0	0	0	0	0	2	17.75	6.75	
04/30/98	0	3	0	0	0	0	0	3	0	0	2	17.00	6.75	
05/01/98	0	0	0	0	0	0	0	0	0	0	2	17.50	6.67	
05/02/98	0	1	0	0	0	0	0	1	0	0	2	17.58	6.00	
05/03/98	0	1	0	0	0	0	0	1	0	0	2	17.75	6.50	
05/04/98	0	0	0	0	0	0	0	0	0	0	2	17.50	7.12	
05/05/98	0	0	0	0	0	0	0	0	0	0	2	17.13	6.25	
05/06/98	1	0	0	0	0	0	1	0	0	0	2	17.00	7.00	
05/07/98	0	1	1	0	0	0	0	1	1	1	2	17.83	6.17	
05/08/98	0	0	0	0	0	0	0	0	0	0	2	17.33	6.83	
05/09/98	0	0	0	0	0	0	0	0	0	0	2	17.33	6.50	
05/10/98	0	0	0	0	0	0	0	0	0	0	2	18.25	5.75	
05/11/98	0	0	0	0	0	0	0	0	0	0	2	17.33	6.75	
05/12/98	0	0	0	0	0	0	0	0	0	0	2	17.42	6.50	
05/13/98	0	1	0	0	0	0	0	1	0	0	2	17.33	7.00	
05/14/98	0	0	0	0	0	0	0	0	0	0	2	17.50	6.33	
05/15/98	0	0	0	0	0	0	0	0	0	0	2	17.33	4.25	
05/16/98	0	0	0	0	0	0	0	0	0	0	2	19.75	7.33	
05/17/98	0	0	0	0	0	0	0	0	0	0	2	17.17	6.17	
05/18/98	1	0	0	0	0	0	1	0	0	0	2	17.50	7.33	
05/19/98	0	0	0	0	0	0	0	0	0	0	2	16.50	6.50	
05/20/98	1	1	0	0	0	0	1	1	0	0	2	17.00	7.00	
05/21/98	1	0	0	0	0	0	0	0	0	0	2	18.42	6.58	
05/22/98	0	0	0	0	0	1	0	0	0	0	2	17.25	6.25	
05/23/98	0	0	0	0	0	0	0	0	0	0	2	17.17	6.83	
05/24/98	0	0	0	0	0	0	0	0	0	0	2	16.67	7.08	
05/25/98	0	0	0	0	0	0	0	0	0	0	2	17.42	6.83	
05/26/98	0	0	0	0	0	0	0	0	0	0	2	17.00	6.67	
05/27/98	0	0	0	0	0	0	0	0	0	0	2	18.71	4.88	
05/28/98	0	0	0	0	0	0	0	0	0	0	2	17.75	6.67	
05/29/98	0	0	0	0	0	0	0	0	0	0	2	17.00	7.50	
05/30/98	0	0	0	0	0	0	0	0	0	0	2	16.50	7.50	
05/31/98	1	0	0	0	0	0	1	0	0	0	2	17.17	7.00	
06/01/98	0	0	0	0	0	0	0	0	0	0	2	17.00	7.25	
06/02/98											2			
06/03/98	0	0	0								2	15.75		
06/04/98	0	0	0								2	18.00	7.00	
06/05/98	0	0	0								2	18.33	4.92	
06/06/98	0	2	0								2	17.92	6.50	
06/07/98	0	0	0								2	17.33	6.67	
06/08/98	0	2	2								2	16.83	7.50	

Appendix B. Daily trapping abundance of juvenile steelhead: December 15, 1997 -- August 2, 1998.

Date	Nocturnal		Diurnal		Daily Totals**		Trap Operations Data			
	YOY	Age 1+	YOY	Age 1+	YOY	Age 1+	Number Fished	Nocturnal (Hours)	Diurnal (Hours)	Non-Diel Specific* (Hours)
		Age 1+ Ad-clip		Age 1+ Ad-clip		Age 1+ Ad-clip				
06/09/98	0	0	0	0	0	0	2	17.17	6.33	
06/10/98	1	0	0	0	1	1	2	17.00	7.00	
06/11/98	1	1	0	0	1	1	2	17.83	6.42	
06/12/98	0	0	1	0	1	0	2	17.42	6.33	
06/13/98	0	1	1	0	1	1	2	17.25	7.08	
06/14/98	1	0	0	0	1	0	2	17.67	6.17	
06/15/98	0	0	1	0	1	0	2	17.33	6.67	
06/16/98	0	0	0	0	0	0	2	17.08	7.00	
06/17/98	0	0	0	0	0	0	2	17.08	7.17	
06/18/98	1	0	0	0	1	0	2	17.50	6.67	
06/19/98	1	0	0	0	1	0	2	16.50	7.33	
06/20/98	1	0	0	0	1	0	2	16.58	7.17	
06/21/98	0	0	0	0	0	0	2	17.25		
06/22/98	0	0	0	0	0	0	1	17.25	6.67	
06/23/98	0	0	0	0	0	0	1	18.00	6.50	
06/24/98	0	0	0	0	0	0	1	16.83	7.00	
06/25/98	1	0	0	0	1	0	1	16.75	6.50	
06/26/98	0	0	0	0	0	0	1	17.50	7.00	
06/27/98	2	0	0	0	2	0	2	17.75	5.37	
06/28/98	1	0	0	0	1	0	2	17.50	6.50	
06/29/98	0	0	0	0	0	0	2	17.67	6.50	
06/30/98	0	0	0	0	0	0	2	17.33	7.00	
07/01/98	0	0	0	0	0	0	2	17.25	6.75	
07/02/98	0	0	0	0	0	0	2	17.17	6.50	
07/03/98	0	0	0	0	0	0	2	17.17	6.83	
07/04/98	0	0	0	0	0	0	2	17.50	7.00	
07/05/98	0	0	0	0	0	0	2	17.33	6.00	
07/06/98	0	0	0	0	0	0	2	17.83	5.17	
07/07/98	0	0	0	0	0	0	2	18.17	7.21	
07/08/98	0	0	1	0	1	0	2	17.17	6.58	
07/09/98	0	0	0	0	0	0	2	17.33		
07/10/98	0	0	0	0	0	0	2	15.08	7.17	
07/11/98	0	0	0	0	0	0	2	17.50		
07/12/98	0	0	0	0	0	0	2	14.58	7.25	
07/13/98	2	0	0	0	2	1	2	16.75	7.17	
07/14/98	0	0	1	0	1	0	2	17.17	4.92	
07/15/98	0	0	0	0	0	0	2	16.67	6.83	
07/16/98	3	0	0	0	0	0	2	17.50	6.67	
07/17/98	1	0	0	0	1	0	2	17.00	7.17	
07/18/98	0	0	0	0	0	0	2	15.50	8.00	
07/19/98	2	0	0	0	2	0	2	17.42	6.33	
07/20/98	2	2	0	0	2	2	2	17.50	7.08	
07/21/98	0	0	0	0	0	0	2	17.17	6.50	
07/22/98	1	0	0	0	1	0	2	17.50	6.67	

Appendix B. Daily trapping abundance of juvenile steelhead: December 15, 1997 -- August 2, 1998.

Date	Nocturnal			Diurnal			Daily Totals**			Trap Operations Data			
	YOY	Age 1+	Age 1+ Ad-clip	YOY	Age 1+	Age 1+ Ad-clip	YOY	Age 1+	Age 1+ Ad-clip	Number Fished	Nocturnal (Hours)	Diurnal (Hours)	Non-Diel Specific* (Hours)
	07/23/98	1	0	0	0	0	0	1	0	0	2	17.17	7.17
07/24/98	1	0	0	0	0	0	1	0	0	2	17.17	6.33	
07/25/98	1	0	0	0	0	0	1	0	0	2	16.00	9.17	
07/26/98	1	0	0	0	0	0	1	0	0	2	16.87	6.63	
07/27/98	0	0	0	0	0	0	0	0	0	2	16.83	6.83	
07/28/98	2	0	0	0	0	0	2	0	0	2	17.17	6.75	
07/29/98	0	0	0	0	0	0	0	0	0	2	17.25	6.83	
07/30/98	0	0	0	0	0	0	0	0	0	2	17.33	6.33	
07/31/98	2	0	0	2	0	0	4	0	0	2	17.50	7.00	
08/01/98	0	0	0	0	0	0	0	0	0	2	16.58	7.17	
08/02/98	2	0	0	0	0	0	2	0	0	2	16.92	6.83	
TOTALS	40	60	33	10	6	2	51	445	387				

* Trap checked once daily or every other day without regard to diel (day/night) intervals.

** Daily totals include fish captured during nocturnal, diurnal, and non-diel specific periods. Therefore, sum of nocturnal and diurnal counts will not always equal daily total if non-diel specific captures occur.

Appendix C. Estimated daily abundance of downstream migrant salmon: December 15, 1997 -- August 2, 1998.

Note: Differences in totals may be attributable to rounding.

Values in parentheses are estimated diel allocations of fish catches over 24 hours or longer.

Date	YOY#	YOY #	Trap Eff	Trap Eff	Est No. YOY	Est No. YOY	Est No. YOY	95% Confidence Interval	
	Day	Night	Day	Night	Day	Night	Total	Hi	Lo
12/15/97	0	0	0.209	0.071	0	0	0	0	0
12/16/97	(0)	(0)	0.209	0.071	0	0	0	0	0
12/17/97	(0)	(4)	0.209	0.071	1	53	54	71	44
12/18/97	(0)	(0)	0.209	0.071	0	0	0	0	0
12/19/97	(0)	(0)	0.209	0.071	0	0	0	0	0
12/20/97	(0)	(6)	0.209	0.071	2	80	82	107	66
12/21/97	(0)	(0)	0.209	0.071	0	0	0	0	0
12/22/97	(0)	(1)	0.209	0.071	0	13	14	18	11
12/23/97	(0)	(0)	0.209	0.071	0	0	0	0	0
12/24/97	(0)	(2)	0.209	0.071	1	27	27	36	22
12/25/97	(0)	(0)	0.209	0.071	0	0	0	0	0
12/26/97	(0)	(6)	0.209	0.071	2	80	82	107	66
12/27/97	(0)	(3)	0.209	0.071	1	40	41	53	33
12/28/97	(0)	(4)	0.209	0.071	1	53	54	71	44
12/29/97	(0)	(7)	0.209	0.071	2	93	95	125	77
12/30/97	(0)	(7)	0.209	0.071	2	93	95	125	77
12/31/97	(1)	(0)	0.209	0.071	3	0	3	4	3
01/01/98	(2)	(12)	0.209	0.071	9	173	182	237	148
01/02/98	(2)	(32)	0.209	0.071	9	453	462	606	374
01/03/98	(3)	(33)	0.209	0.071	12	467	479	627	388
01/04/98	(2)	(46)	0.209	0.071	10	654	664	870	537
01/05/98	(7)	(38)	0.209	0.071	34	534	567	739	461
01/06/98	(3)	(126)	0.209	0.071	16	1774	1790	2350	1446
01/07/98	(2)	(60)	0.209	0.071	11	840	851	1117	688
01/08/98	(3)	(40)	0.209	0.071	16	560	576	754	466
01/09/98	(2)	(59)	0.209	0.071	10	627	637	1099	677
01/10/98	(2)	(39)	0.209	0.071	10	547	556	730	450
01/11/98	(2)	(36)	0.209	0.071	11	507	518	679	419
01/12/98	(8)	(43)	0.209	0.071	39	600	639	832	520
01/13/98	72	(146)	0.209	0.071	344	2054	2399	3080	1973
01/14/98	32	1017	0.209	0.071	153	14324	14477	19002	11697
01/15/98	32	463	0.209	0.071	153	6521	6674	8742	5402
01/16/98	(39)	759	0.209	0.071	186	10690	10876	14260	8795
01/17/98	(49)	(694)	0.209	0.071	235	9777	10012	13113	8103
01/18/98	(42)	(877)	0.209	0.071	199	12351	12550	16458	10148
01/19/98	58	(743)	0.209	0.071	278	10470	10748	14072	8702
01/20/98	37	3896	0.209	0.071	177	54873	55050	72343	44435
01/21/98	22	1107	0.209	0.071	105	15592	15697	20616	12676
01/22/98	58	875	0.209	0.071	278	12324	12601	16509	10198
01/23/98	56	1223	0.209	0.071	268	17225	17493	22943	14143
01/24/98	104	2080	0.209	0.071	498	29296	29793	39066	24093
01/25/98	(105)	(2796)	0.209	0.071	502	39380	39882	52330	32233
01/26/98	104	(1874)	0.209	0.071	498	26396	26894	35253	21753
01/27/98	168	3353	0.209	0.071	804	47225	48029	62977	38839
01/28/98	234	3452	0.209	0.071	1120	48620	49739	65158	40254
01/29/98	104	3263	0.209	0.071	498	45958	46455	60973	37536
01/30/98	98	6829	0.209	0.071	469	96183	96652	126979	78032
01/31/98	(99)	5319	0.209	0.071	474	74915	75389	98021	60878
02/01/98	(89)	(1770)	0.209	0.071	427	24929	25356	33246	20504
02/02/98	17	(1595)	0.209	0.071	81	22461	22543	29622	18197
02/03/98	800	2183	0.209	0.071	3828	30746	34574	44636	28316
02/04/98	(554)	(7976)	0.095	0.024	5836	332315	338151	405225	290172
02/05/98	112	1176	0.095	0.024	1179	49000	50179	60102	43077
02/06/98			0.095	0.024				0	0

Appendix C. Estimated daily abundance of downstream migrant salmon: December 15, 1997 -- August 2, 1998.

Note: Differences in totals may be attributable to rounding.

Values in parentheses are estimated diel allocations of fish catches over 24 hours or longer.

Date	YOY#		Trap Eff		Est No. YOY		Est No. YOY Total	95% Confidence Interval	
	Day	Night	Day	Night	Day	Night		Hi	Lo
02/07/98	(20)	852	0.095	0.024	208	35500	35708	42830	30619
02/08/98	(20)	(284)	0.095	0.024	207	11843	12050	14440	10340
02/09/98	29	(282)	0.095	0.024	305	11765	12071	14456	10363
02/10/98	41	988	0.095	0.024	432	41167	41598	49877	35680
02/11/98	25	423	0.095	0.024	263	17625	17888	21441	15348
02/12/98	(8)	146	0.095	0.024	89	6083	6172	7398	5296
02/13/98	8	(122)	0.095	0.024	84	5065	5149	6171	4418
02/14/98	13	97	0.095	0.024	137	4042	4179	5001	3589
02/15/98	3	147	0.095	0.024	32	6125	6157	7385	5279
02/16/98	6	35	0.095	0.024	63	1458	1521	1820	1308
02/17/98	12	49	0.095	0.024	126	2042	2168	2590	1865
02/18/98	12	203	0.095	0.024	126	8458	8585	10290	7365
02/19/98	7	81	0.095	0.024	74	3375	3449	4131	2960
02/20/98	13	92	0.095	0.024	137	3833	3970	4751	3411
02/21/98	5	102	0.095	0.024	53	4250	4303	5158	3691
02/22/98	13	181	0.095	0.024	137	7542	7679	9201	6589
02/23/98	6	99	0.095	0.024	63	4125	4188	5020	3593
02/24/98	30	222	0.095	0.024	316	9250	9566	11449	8217
02/25/98	20	155	0.095	0.024	211	6458	6669	7983	5728
02/26/98	12	227	0.095	0.024	126	9458	9585	11490	8223
02/27/98	15	341	0.095	0.024	158	14208	14366	17224	12323
02/28/98	20	254	0.095	0.024	211	10583	10794	12933	9264
03/01/98	19	212	0.095	0.024	200	8833	9033	10821	7754
03/02/98	19	90	0.095	0.024	200	3750	3950	4721	3397
03/03/98	5	83	0.095	0.024	53	3458	3511	4208	3012
03/04/98	4	56	0.095	0.024	42	2333	2375	2847	2038
03/05/98	2	89	0.095	0.024	21	3708	3729	4473	3198
03/06/98	1	69	0.095	0.024	11	2875	2886	3462	2474
03/07/98	7	156	0.095	0.024	74	6500	6574	7881	5639
03/08/98	1	46	0.095	0.024	11	1917	1927	2312	1652
03/09/98	4	40	0.095	0.024	42	1667	1709	2047	1467
03/10/98	9	44	0.095	0.024	95	1833	1926	2305	1658
03/11/98	2	34	0.095	0.024	21	1417	1438	1723	1234
03/12/98	1	38	0.095	0.024	11	1583	1594	1912	1367
03/13/98	3	28	0.095	0.024	32	1167	1198	1435	1029
03/14/98	0	42	0.095	0.024	0	1750	1750	2100	1500
03/15/98	(7)	0	0.163	0.048	43	0	43	50	38
03/16/98	5	(49)	0.163	0.048	31	1020	1050	1434	828
03/17/98	2	32	0.163	0.048	12	667	679	928	535
03/18/98	0	28	0.163	0.048	0	583	583	800	459
03/19/98	1	11	0.163	0.048	6	229	235	321	186
03/20/98	10	54	0.163	0.048	61	1125	1186	1614	939
03/21/98	6	40	0.191	0.113	31	354	385	468	288
03/22/98	1	34	0.191	0.113	5	301	306	372	227
03/23/98	1	17	0.191	0.113	5	150	156	189	116
03/24/98	3	24	0.191	0.113	16	212	228	277	170
03/25/98	7	26	0.191	0.113	37	230	267	324	201
03/26/98	36	41	0.191	0.113	188	363	551	669	429
03/27/98	30	182	0.191	0.113	157	1611	1768	2147	1323
03/28/98	7	370	0.191	0.113	37	3274	3311	4023	2450
03/29/98	36	210	0.191	0.113	188	1858	2047	2486	1533
03/30/98	51	497	0.191	0.113	267	4398	4665	5667	3476
03/31/98	115	1060	0.191	0.113	602	9381	9983	12126	7441
04/01/98	24	919	0.191	0.113	126	8133	8258	10034	6114

Appendix C. Estimated daily abundance of downstream migrant salmon: December 15, 1997 -- August 2, 1998.

Note: Differences in totals may be attributable to rounding.

Values in parentheses are estimated diel allocations of fish catches over 24 hours or longer.

Date	YOY#	YOY #	Trap Eff		Est No. YOY		Est No. YOY	95% Confidence Interval
	Day	Night	Day	Night	Day	Night	Total	
04/02/98	14	508	0.191	0.113	73	4496	4569	5551 3383
04/03/98	37	282	0.191	0.113	194	2496	2689	3266 2008
04/04/98	39	802	0.191	0.113	204	5327	5532	6720 4109
04/05/98	51	579	0.191	0.113	267	5124	5391	6549 4012
04/06/98	27	522	0.191	0.113	141	4619	4761	5764 3532
04/07/98	113	762	0.191	0.113	592	6743	7335	8909 5465
04/08/98	142	1263	0.191	0.113	743	11177	11920	14479 8889
04/09/98	46	491	0.191	0.113	241	4345	4586	5571 3415
04/10/98	65	572	0.141	0.123	461	4650	5111	6095 4401
04/11/98	93	621	0.141	0.123	660	5049	5708	6804 4917
04/12/98	91	660	0.141	0.123	645	5366	6011	7166 5177
04/13/98	35	532	0.141	0.123	248	4325	4573	5457 3936
04/14/98	131	446	0.141	0.123	929	3626	4555	5422 3928
04/15/98	21	812	0.141	0.123	149	6602	6751	8058 5808
04/16/98	61	420	0.141	0.123	433	3415	3847	4586 3314
04/17/98	43	687	0.141	0.123	305	5585	5890	7028 5070
04/18/98	7	245	0.141	0.123	50	1992	2042	2437 1756
04/19/98	4	227	0.141	0.123	28	1846	1874	2237 1612
04/20/98	4	108	0.141	0.123	28	878	906	1082 780
04/21/98	54	111	0.141	0.123	383	902	1285	1528 1110
04/22/98	10	177	0.141	0.123	71	1439	1510	1802 1299
04/23/98	13	194	0.141	0.123	92	1577	1669	1992 1437
04/24/98	80	266	0.141	0.123	567	2163	2730	3249 2354
04/25/98	111	512	0.141	0.123	787	4163	4950	5896 4266
04/26/98	20	161	0.141	0.123	142	1309	1451	1730 1249
04/27/98	6	148	0.141	0.123	43	1203	1246	1487 1072
04/28/98	9	32	0.141	0.123	64	260	324	386 279
04/29/98	19	210	0.141	0.123	135	1707	1842	2197 1586
04/30/98	49	357	0.141	0.123	348	2902	3250	3874 2799
05/01/98	34	440	0.189	0.117	180	3761	3941	4558 3471
05/02/98	85	534	0.189	0.117	450	4564	5014	5790 4422
05/03/98	81	861	0.189	0.117	429	7359	7788	9004 6861
05/04/98	162	936	0.189	0.117	857	8000	8857	10226 7813
05/05/98	145	1354	0.189	0.117	767	11573	12340	14264 10874
05/06/98	476	2225	0.189	0.117	2519	19017	21536	24846 19007
05/07/98	81	3140	0.189	0.117	429	26838	27266	31568 23997
05/08/98	65	1158	0.189	0.117	344	9897	10241	11850 9018
05/09/98	118	1045	0.189	0.117	624	8932	9556	11045 8422
05/10/98	58	499	0.189	0.117	307	4265	4572	5284 4029
05/11/98	203	2306	0.189	0.117	1074	19709	20783	24033 18310
05/12/98	121	1166	0.189	0.117	640	9966	10606	12261 9346
05/13/98	127	1141	0.189	0.117	672	9752	10424	12049 9187
05/14/98	366	421	0.189	0.117	1937	3596	5535	6334 4917
05/15/98	196	1568	0.189	0.117	1037	13402	14439	16685 12727
05/16/98	260	1564	0.189	0.117	1376	13368	14743	17024 13003
05/17/98	96	400	0.189	0.117	508	3419	3927	4528 3467
05/18/98	175	969	0.189	0.117	926	8262	9208	10630 8123
05/19/98	240	219	0.189	0.117	1270	1872	3142	3588 2795
05/20/98	195	757	0.189	0.117	1032	6470	7502	8649 6625
05/21/98	75	595	0.189	0.117	397	5085	5482	6335 4833
05/22/98	122	383	0.189	0.117	646	3274	3919	4514 3463
05/23/98	80	440	0.189	0.117	423	3761	4184	4830 3691
05/24/98	128	383	0.189	0.117	677	3274	3951	4549 3492
05/25/98	97	393	0.189	0.117	513	3359	3872	4465 3419

Appendix C. Estimated daily abundance of downstream migrant salmon: December 15, 1997 -- August 2, 1998.

Note: Differences in totals may be attributable to rounding.

Values in parentheses are estimated diel allocations of fish catches over 24 hours or longer.

Date	YOY#	YOY #	Trap Eff	Trap Eff	Est No. YOY	Est No. YOY	Est No. YOY	95% Confidence Interval	
	Day	Night	Day	Night	Day	Night	Total	Hi	Lo
05/26/98	34	376	0.189	0.117	180	3214	3394	3924	2990
05/27/98	41	204	0.189	0.117	217	1744	1961	2262	1730
05/28/98	44	587	0.189	0.117	233	5017	5250	6072	4624
05/29/98	256	756	0.189	0.117	1354	6462	7816	9000	6909
05/30/98	218	426	0.189	0.117	1153	3641	4794	5508	4246
05/31/98	132	703	0.189	0.117	698	6009	6707	7741	5917
06/01/98	157	564	0.189	0.117	831	4821	5651	6513	4992
06/02/98	0	0	0.189	0.117	0	0	0	0	0
06/03/98	0	177	0.189	0.117	0	1513	1513	1752	1331
06/04/98	143	132	0.189	0.117	757	1128	1885	2153	1677
06/05/98	159	777	0.189	0.117	841	6641	7482	8634	6603
06/06/98	163	562	0.189	0.117	862	4803	5666	6529	5005
06/07/98	89	457	0.189	0.117	365	3906	4271	4933	3766
06/08/98	240	419	0.189	0.117	1270	3581	4851	5589	4299
06/09/98	255	747	0.189	0.117	1349	6385	7734	8905	6837
06/10/98	129	707	0.189	0.117	683	6043	6725	7763	5933
06/11/98	106	612	0.189	0.117	561	4376	4937	5697	4357
06/12/98	299	222	0.189	0.117	1582	1897	3479	3967	3100
06/13/98	193	564	0.189	0.117	1021	4821	5842	6726	5164
06/14/98	71	379	0.189	0.117	376	3239	3615	4173	3189
06/15/98	161	270	0.189	0.117	852	2308	3160	3626	2800
06/16/98	99	349	0.189	0.117	524	2983	3507	4041	3098
06/17/98	68	223	0.189	0.117	360	1906	2266	2610	2002
06/18/98	45	203	0.189	0.117	238	1735	1973	2276	1742
06/19/98	134	153	0.189	0.117	709	1308	2017	2308	1792
06/20/98	62	231	0.189	0.117	328	1974	2302	2654	2033
06/21/98	0	22	0.189	0.117	0	188	188	218	165
06/22/98	25	75	0.020	0.009	1250	8333	9583	156250	4444
06/23/98	22	52	0.020	0.009	1100	5778	6878	109500	3211
06/24/98	3	6	0.020	0.009	150	667	817	12750	383
06/25/98	5	11	0.020	0.009	250	1222	1472	23250	689
06/26/98	4	6	0.020	0.009	200	667	867	13000	411
06/27/98	2	7	0.072	0.009	28	778	806	14039	372
06/28/98	5	1	0.072	0.018	69	56	125	241	88
06/29/98	0	2	0.072	0.018	0	111	111	286	69
06/30/98	2	4	0.072	0.018	28	222	250	611	159
07/01/98	0	11	0.072	0.018	0	611	611	1571	379
07/02/98	0	7	0.072	0.018	0	389	389	1000	241
07/03/98	1	5	0.072	0.018	14	278	292	734	183
07/04/98	3	0	0.072	0.018	42	0	42	59	32
07/05/98	1	0	0.072	0.018	14	0	14	20	11
07/06/98	0	2	0.072	0.018	0	111	111	286	69
07/07/98	0	6	0.072	0.018	0	333	333	857	207
07/08/98	1	4	0.072	0.018	14	222	236	591	149
07/09/98	0	4	0.072	0.018	0	222	222	571	138
07/10/98	1	2	0.072	0.018	14	111	125	305	80
07/11/98	0	1	0.035	0.008	0	125	125	1000	67
07/12/98	1	0	0.035	0.008	29	0	29	48	20
07/13/98	1	1	0.035	0.008	29	125	154	1048	87
07/14/98	0	1	0.035	0.008	0	125	125	1000	67
07/15/98	0	2	0.035	0.008	0	250	250	2000	133
07/16/98	0	3	0.035	0.008	0	375	375	3000	200
07/17/98	0	0	0.106	0.128	0	0	0	0	0
07/18/98	0	0	0.106	0.128	0	0	0	0	0

Appendix C. Estimated daily abundance of downstream migrant salmon: December 15, 1997 -- August 2, 1998.

Note: Differences in totals may be attributable to rounding.

Values in parentheses are estimated diel allocations of fish catches over 24 hours or longer.

Date	YOY#		Trap Eff		Est No. YOY			95% Confidence Interval	
	Day	Night	Day	Night	Day	Night	Total	Hi	Lo
07/19/98	0	0	0.106	0.128	0	0	0	0	0
07/20/98	0	0	0.106	0.128	0	0	0	0	0
07/21/98	0	0	0.106	0.128	0	0	0	0	0
07/22/98	0	0	0.106	0.128	0	0	0	0	0
07/23/98	0	2	0.106	0.128	0	16	16	22	12
07/24/98	0	0	0.106	0.128	0	0	0	0	0
07/25/98	0	0	0.106	0.128	0	0	0	0	0
07/26/98	0	0	0.106	0.128	0	0	0	0	0
07/27/98	0	0	0.106	0.128	0	0	0	0	0
07/28/98	0	2	0.106	0.128	0	16	16	22	12
07/29/98	0	0	0.106	0.128	0	0	0	0	0
07/30/98	0	0	0.106	0.128	0	0	0	0	0
07/31/98	3	0	0.106	0.128	28	0	28	42	21
08/01/98	0	1	0.106	0.128	0	8	8	11	6
08/02/98	0	1	0.106	0.128	0	8	8	11	6
TOTAL:	12423	114415			74625	1773914	1848539	2592219	1543355

Appendix D. Daily average size of YOY salmon captured at Woodbridge Dam - Traps 1 and 2: December 15, 1997 -- August 2, 1998.

Date	Avg TL, mm	Avg FL, mm	Avg Wt, g	Avg K	Std TL	Std FL	Std Wt	Std K	Max TL, mm	Min TL, mm	Max Wt, g	Min Wt, g	N
12/15/97													0
12/16/97													0
12/17/97	35	34	0.2	5.15E-004	0.6	0.6	0.06	1.08E-004	36	35	0.3	0.2	4
12/18/97													0
12/19/97													0
12/20/97	37	35	0.3	5.84E-004	0.9	0.9	0.00	3.58E-005	38	36	0.3	0.3	5
12/21/97													0
12/22/97	36	35	0.3	6.43E-004	0.0	0.0	0.00		36	36	0.3	0.3	1
12/23/97													0
12/24/97	36	34	0.2	4.48E-004	1.0	2.0	0.00	1.89E-005	36	35	0.2	0.2	2
12/25/97													0
12/26/97	36	35	0.3	6.40E-004	1.5	1.5	0.04	1.21E-004	37	33	0.3	0.2	6
12/27/97	37	36	0.3	5.43E-004	0.7	0.7	0.07	1.07E-004	37	36	0.3	0.2	3
12/28/97	37	36	0.3	6.38E-004	0.7	0.7	0.07	6.44E-005	38	37	0.4	0.3	3
12/29/97	35	34	0.3	6.47E-004	0.9	1.2	0.05	1.16E-004	36	34	0.3	0.2	5
12/30/97	37	35	0.3	5.22E-004	1.2	0.9	0.06	1.06E-004	38	35	0.3	0.2	7
12/31/97													0
01/01/98	36	35	0.3	5.55E-004	1.6	1.6	0.05	8.21E-005	38	33	0.3	0.2	12
01/02/98	37	36	0.3	5.06E-004	1.1	1.1	0.05	8.65E-005	39	35	0.3	0.2	14
01/03/98	36	35	0.3	5.71E-004	1.2	1.1	0.06	1.02E-004	38	34	0.4	0.2	19
01/04/98	38	36	0.3	5.20E-004	1.2	1.3	0.06	9.16E-005	40	36	0.4	0.2	20
01/05/98	37	36	0.3	5.68E-004	1.3	1.3	0.06	9.06E-005	40	34	0.4	0.2	37
01/06/98	37	36	0.3	5.89E-004	1.3	1.1	0.09	1.43E-004	39	33	0.5	0.1	60
01/07/98	37	36	0.3	5.80E-004	1.5	1.3	0.06	9.91E-005	40	33	0.4	0.2	48
01/08/98	38	36	0.3	5.89E-004	1.4	1.3	0.06	9.15E-005	41	35	0.4	0.2	40
01/09/98	37	36	0.3	6.25E-004	1.9	1.7	0.07	1.18E-004	39	27	0.4	0.1	42
01/10/98	38	36	0.3	5.89E-004	1.5	1.3	0.07	7.62E-005	43	34	0.5	0.2	35
01/11/98	38	37	0.3	5.83E-004	1.1	1.0	0.07	9.35E-005	41	36	0.5	0.2	36
01/12/98	38	37	0.3	5.75E-004	1.3	1.3	0.05	8.55E-005	40	35	0.4	0.2	35

Appendix D. Daily average size of YOY salmon captured at Woodbridge Dam - Traps 1 and 2: December 15, 1997 -- August 2, 1998.

Date	Avg TL, mm	Avg FL, mm	Avg Wt, g	Avg K	Std TL	Std FL	Std Wt	Std K	Max TL, mm	Min TL, mm	Max Wt, g	Min Wt, g	N
01/13/98	38	37	0.3	6.24E-004	1.5	1.3	0.08	1.23E-004	41	35	0.5	0.2	32
01/14/98	38	36	0.3	5.89E-004	1.3	1.2	0.06	8.14E-005	41	34	0.4	0.2	60
01/15/98	38	37	0.3	5.74E-004	1.3	1.3	0.06	8.03E-005	41	36	0.4	0.2	60
01/16/98	38	37	0.3	6.04E-004	1.5	1.2	0.08	9.73E-005	42	35	0.6	0.2	60
01/17/98	38	37	0.3	6.17E-004	1.6	1.2	0.08	1.07E-004	41	35	0.5	0.2	60
01/18/98	38	37	0.3	5.84E-004	1.6	1.5	0.06	8.42E-005	42	34	0.5	0.2	60
01/19/98	38	37	0.3	5.72E-004	1.4	1.3	0.04	6.83E-005	42	36	0.4	0.3	60
01/20/98	38	37	0.3	5.87E-004	1.2	1.2	0.05	6.52E-005	41	35	0.4	0.3	60
01/21/98	39	37	0.4	6.10E-004	1.4	1.2	0.08	8.82E-005	42	36	0.6	0.2	60
01/22/98	38	37	0.3	5.93E-004	1.5	1.2	0.06	8.73E-005	41	35	0.5	0.2	60
01/23/98	37	35	0.3	6.72E-004	1.5	1.4	0.06	9.35E-005	40	34	0.5	0.2	60
01/24/98	38	36	0.3	6.01E-004	2.0	1.9	0.07	9.72E-005	42	32	0.4	0.2	60
01/25/98	39	37	0.4	5.97E-004	1.5	1.3	0.07	7.21E-005	42	36	0.5	0.2	60
01/26/98	39	37	0.4	6.06E-004	1.3	1.2	0.07	9.76E-005	42	35	0.5	0.2	60
01/27/98	39	37	0.4	5.86E-004	1.9	1.8	0.07	9.11E-005	43	34	0.5	0.2	60
01/28/98	39	37	0.4	6.21E-004	1.9	1.6	0.08	1.34E-004	45	33	0.5	0.3	60
01/29/98	39	37	0.4	5.94E-004	1.7	1.3	0.07	7.85E-005	44	34	0.5	0.2	60
01/30/98	39	38	0.4	5.85E-004	1.3	1.2	0.07	8.87E-005	42	36	0.5	0.2	60
01/31/98	39	38	0.4	5.83E-004	1.4	1.4	0.05	7.40E-005	44	36	0.5	0.3	60
02/01/98	39	37	0.4	6.20E-004	1.7	1.4	0.06	6.94E-005	43	35	0.5	0.2	60
02/02/98	39	37	0.4	5.89E-004	1.4	1.3	0.06	7.58E-005	42	36	0.5	0.2	60
02/03/98	39	37	0.3	6.01E-004	1.6	1.4	0.06	7.93E-005	41	34	0.5	0.2	60
02/04/98													0
02/05/98	39	38	0.4	6.29E-004	1.5	1.3	0.06	8.23E-005	42	37	0.6	0.3	60
02/06/98													0
02/07/98	39	37	0.4	6.02E-004	1.6	1.4	0.07	8.78E-005	42	35	0.5	0.2	61
02/08/98	39	37	0.4	5.99E-004	2.0	1.8	0.07	7.58E-005	43	34	0.5	0.2	60
02/09/98	40	38	0.4	6.34E-004	3.2	2.7	0.14	9.88E-005	59	36	1.3	0.2	60
02/10/98	39	38	0.4	5.88E-004	1.9	1.6	0.07	6.21E-005	43	35	0.5	0.2	60

Appendix D. Daily average size of YOY salmon captured at Woodbridge Dam - Traps 1 and 2: December 15, 1997 -- August 2, 1998.

Date	Avg TL, mm	Avg FL, mm	Avg Wt, g	Avg K	Std TL	Std FL	Std Wt	Std K	Max TL, mm	Min TL, mm	Max Wt, g	Min Wt, g	N
02/11/98	40	38	0.4	6.25E-004	2.5	2.2	0.11	7.67E-005	54	36	1.1	0.2	60
02/12/98	40	38	0.4	6.24E-004	2.2	1.9	0.07	6.19E-005	45	34	0.6	0.3	57
02/13/98	39	37	0.4	6.06E-004	1.5	1.2	0.08	1.02E-004	42	36	0.6	0.2	39
02/14/98	39	38	0.4	6.09E-004	2.0	1.7	0.08	7.35E-005	44	36	0.6	0.2	49
02/15/98	39	37	0.4	6.11E-004	2.0	1.8	0.06	1.01E-004	43	30	0.5	0.3	60
02/16/98	39	38	0.4	6.13E-004	2.1	1.9	0.10	9.82E-005	43	34	0.5	0.2	34
02/17/98	39	37	0.4	6.18E-004	2.5	2.0	0.13	7.77E-005	48	35	1	0.2	35
02/18/98	39	37	0.4	6.23E-004	1.7	1.4	0.06	8.47E-005	43	36	0.5	0.3	60
02/19/98	39	37	0.4	5.84E-004	3.6	3.2	0.19	1.02E-004	60	32	1.6	0.2	50
02/20/98	39	37	0.4	6.21E-004	1.4	1.3	0.06	9.33E-005	44	37	0.5	0.2	41
02/21/98	39	38	0.4	6.16E-004	1.8	1.7	0.08	8.42E-005	45	36	0.5	0.2	50
02/22/98	39	38	0.4	5.84E-004	1.8	1.6	0.07	7.60E-005	44	37	0.6	0.2	60
02/23/98	40	38	0.4	6.13E-004	2.4	2.1	0.11	9.80E-005	48	35	0.8	0.2	54
02/24/98	40	38	0.4	6.32E-004	2.5	2.3	0.09	7.25E-005	49	34	0.8	0.3	60
02/25/98	39	38	0.4	6.11E-004	2.0	1.8	0.09	8.18E-005	46	36	0.7	0.3	60
02/26/98	39	37	0.4	6.03E-004	1.7	1.5	0.07	8.28E-005	45	36	0.6	0.2	60
02/27/98	40	38	0.4	6.13E-004	1.7	1.5	0.06	5.38E-005	43	36	0.5	0.3	60
02/28/98	40	38	0.4	6.00E-004	4.6	4.3	0.32	7.27E-005	70	36	2.7	0.2	60
03/01/98	39	37	0.4	6.10E-004	1.7	1.6	0.08	7.37E-005	47	37	0.8	0.3	60
03/02/98	39	38	0.4	5.97E-004	3.7	3.4	0.19	7.81E-005	62	35	1.7	0.2	60
03/03/98	39	37	0.4	5.89E-004	2.5	2.2	0.10	7.93E-005	55	35	1	0.2	60
03/04/98	40	38	0.4	5.87E-004	3.3	3.1	0.15	7.98E-005	52	32	1.1	0.1	34
03/05/98	42	40	0.5	5.81E-004	8.2	7.3	0.51	1.15E-004	71	28	2.7	0.2	61
03/06/98	41	39	0.5	6.22E-004	6.9	6.2	0.43	8.91E-005	67	36	2.4	0.2	57
03/07/98	40	38	0.4	6.16E-004	4.1	3.7	0.22	9.53E-005	60	35	1.5	0.2	60
03/08/98	41	39	0.5	6.42E-004	6.4	5.7	0.41	1.09E-004	72	27	2.7	0.2	41
03/09/98	42	40	0.5	6.19E-004	7.1	6.4	0.40	1.13E-004	67	38	2	0.3	37
03/10/98	41	39	0.5	6.46E-004	9.2	8.2	0.78	1.08E-004	90	32	5.2	0.1	42
03/11/98	40	38	0.4	6.14E-004	3.3	3.1	0.14	9.19E-005	51	32	0.9	0.2	33

Appendix D. Daily average size of YOY salmon captured at Woodbridge Dam - Traps 1 and 2: December 15, 1997 -- August 2, 1998.

Date	Avg TL, mm	Avg FL, mm	Avg Wt, g	Avg K	Std TL	Std FL	Std Wt	Std K	Max TL, mm	Min TL, mm	Max Wt, g	Min Wt, g	N
03/12/98	42	40	0.5	5.91E-004	7.9	7.1	0.60	7.26E-005	80	27	3.8	0.1	36
03/13/98	40	38	0.4	6.49E-004	5.5	5.1	0.21	1.27E-004	55	22	1.4	0.1	28
03/14/98	42	40	0.5	6.24E-004	7.0	6.2	0.43	7.23E-005	68	37	2.2	0.3	40
03/15/98													0
03/16/98	51	48	1.2	6.76E-004	13.6	12.2	1.01	8.64E-005	77	35	3.6	0.3	43
03/17/98	49	46	1.0	6.48E-004	14.0	12.6	1.12	1.04E-004	80	35	4.3	0.2	32
03/18/98	49	46	1.1	6.70E-004	15.5	14.0	1.27	1.03E-004	84	28	4.8	0.2	28
03/19/98	50	47	1.3	6.20E-004	20.3	18.2	1.81	1.26E-004	91	31	5.6	0.1	11
03/20/98	45	43	0.9	6.26E-004	14.3	12.8	1.23	8.07E-005	95	32	6.5	0.2	51
03/21/98	54	50	1.5	6.41E-004	18.7	16.7	1.84	1.04E-004	101	37	8.8	0.3	40
03/22/98	66	61	2.7	6.98E-004	19.9	17.6	2.02	9.91E-005	96	35	7	0.2	31
03/23/98	67	62	2.9	7.25E-004	21.1	18.9	2.65	1.19E-004	102	39	9.7	0.3	15
03/24/98	80	74	4.3	7.35E-004	15.9	14.1	2.09	6.07E-005	100	41	8.2	0.4	20
03/25/98	75	69	3.6	7.29E-004	17.6	15.9	2.19	6.33E-005	98	37	7.8	0.3	26
03/26/98	77	71	3.9	7.59E-004	14.7	13.1	2.17	6.32E-005	100	40	8.5	0.4	30
03/27/98	80	75	4.0	7.33E-004	8.8	8.0	1.64	4.61E-005	112	60	12.3	1.7	60
03/28/98	80	74	3.9	7.50E-004	7.0	6.5	1.22	8.87E-005	95	65	9.1	2	60
03/29/98	80	75	3.9	7.31E-004	7.6	6.9	1.19	5.14E-005	99	59	8.3	1.4	60
03/30/98	79	73	3.6	7.19E-004	7.5	6.7	1.06	4.79E-005	96	58	7.5	1.2	60
03/31/98	78	72	3.4	7.07E-004	8.7	8.0	1.10	5.56E-005	97	53	6.2	1	60
04/01/98	80	74	3.8	7.11E-004	7.4	6.6	1.14	4.21E-005	99	61	7.2	1.6	60
04/02/98	79	72	3.5	7.01E-004	8.9	8.2	1.30	5.70E-005	102	59	7.9	1.2	60
04/03/98	83	77	4.1	7.08E-004	8.2	7.8	1.28	8.06E-005	98	62	7.6	1.6	60
04/04/98	79	73	3.6	6.87E-004	10.0	8.9	1.21	3.60E-005	97	47	6.3	0.7	60
04/05/98	81	75	3.9	7.11E-004	7.6	6.8	1.05	3.77E-005	98	55	6.8	1.2	60
04/06/98	84	77	4.2	6.92E-004	9.4	8.5	1.45	3.84E-005	104	62	7.9	1.6	60
04/07/98	85	78	4.4	6.97E-004	9.5	8.6	1.49	3.56E-005	108	64	8.8	1.8	60
04/08/98	83	76	4.0	6.79E-004	8.3	7.7	1.21	5.21E-005	97	63	7.1	1.6	60
04/09/98	83	76	4.2	6.92E-004	10.1	9.2	1.42	4.64E-005	102	56	7.8	1	60

Appendix D. Daily average size of YOY salmon captured at Woodbridge Dam - Traps 1 and 2: December 15, 1997 -- August 2, 1998.

Date	Avg TL, mm	Avg FL, mm	Avg Wt, g	Avg K	Std TL	Std FL	Std Wt	Std K	Max TL, mm	Min TL, mm	Max Wt, g	Min Wt, g	N
04/10/98	85	78	4.4	6.88E-004	8.7	7.7	1.29	3.49E-005	103	65	7.8	1.9	60
04/11/98	85	78	4.4	7.05E-004	7.7	6.6	1.14	3.12E-005	98	61	7.1	1.7	60
04/12/98	87	79	4.6	6.95E-004	7.8	7.0	1.26	4.23E-005	102	68	7.5	2.1	60
04/13/98	83	76	4.2	7.08E-004	8.9	8.0	1.32	3.93E-005	100	64	7.5	1.8	60
04/14/98	85	78	4.3	6.89E-004	9.1	8.2	1.40	3.31E-005	102	64	8.5	1.8	32
04/15/98	87	80	4.7	6.98E-004	7.2	6.5	1.16	4.81E-005	101	67	7.6	2.2	60
04/16/98	87	80	4.6	6.91E-004	7.2	6.4	1.14	4.93E-005	102	69	7.4	2.2	60
04/17/98	89	81	5.0	6.96E-004	7.0	6.4	1.20	3.12E-005	105	75	8	2.9	60
04/18/98	93	85	5.8	7.05E-004	6.7	6.0	1.22	3.50E-005	107	68	9	2.3	60
04/19/98	92	84	5.5	6.97E-004	7.0	6.3	1.25	5.42E-005	105	64	9	1.9	60
04/20/98	93	86	5.9	7.14E-004	6.4	5.8	1.24	5.18E-005	109	79	9.1	3.6	60
04/21/98	95	86	6.0	7.02E-004	7.8	7.0	1.60	4.13E-005	115	66	11.7	2.2	46
04/22/98	94	86	6.1	7.23E-004	8.7	8.0	1.68	5.52E-005	114	57	11	1.1	51
04/23/98	91	83	5.7	7.23E-004	11.7	10.4	1.78	4.04E-005	115	62	10.5	1.7	49
04/24/98	93	85	6.0	7.19E-004	9.7	8.9	1.77	4.80E-005	113	58	10.8	1.9	60
04/25/98	94	86	5.9	6.85E-004	9.9	8.9	1.80	5.36E-005	122	45	14.6	0.5	53
04/26/98	95	86	6.0	6.87E-004	5.3	4.8	1.08	3.38E-005	108	78	9.6	3.1	60
04/27/98	97	88	6.6	7.23E-004	5.6	5.1	1.20	3.63E-005	108	84	9.8	4.3	55
04/28/98	97	90	6.9	7.24E-004	12.2	9.9	2.36	4.26E-005	112	71	10.5	2.6	12
04/29/98	98	89	7.2	7.34E-004	8.3	7.7	1.92	3.78E-005	121	72	14.6	2.6	60
04/30/98	98	90	7.0	7.37E-004	6.64	5.91	1.62	5.09E-005	118	86	12	4.7	60
05/01/98	98	89	6.8	7.14E-004	7.9	7.2	1.66	3.52E-005	116	68	11.6	2.3	60
05/02/98	98	89	7.0	7.33E-004	6.6	6.0	1.55	3.91E-005	112	81	11.5	4.1	60
05/03/98	99	90	7.1	7.28E-004	5.9	5.5	1.40	3.89E-005	110	84	10.5	4.1	60
05/04/98	99	90	7.1	7.28E-004	6.6	6.2	1.54	3.03E-005	116	88	11	5.1	60
05/05/98	100	91	7.4	7.39E-004	6.5	6.1	1.64	4.04E-005	120	87	12.2	4.8	60
05/06/98	102	93	7.7	7.14E-004	6.2	5.9	1.64	5.95E-005	115	90	11.7	5.1	60
05/07/98	96	88	6.6	7.26E-004	7.4	7.0	1.65	3.64E-005	111	82	10.6	4	30
05/08/98	100	91	7.4	7.13E-004	7.9	7.1	2.02	4.52E-005	120	84	13.8	4.1	60

Appendix D. Daily average size of YOY salmon captured at Woodbridge Dam - Traps 1 and 2: December 15, 1997 -- August 2, 1998.

Date	Avg TL, mm	Avg FL, mm	Avg Wt, g	Avg K	Std TL	Std FL	Std Wt	Std K	Max TL, mm	Min TL, mm	Max Wt, g	Min Wt, g	N
05/09/98	101	92	7.9	7.41E-004	8.2	7.4	2.11	4.00E-005	124	85	13.9	4.6	60
05/10/98	101	92	7.8	7.41E-004	8.3	7.5	2.11	4.01E-005	122	82	13.6	3.8	60
05/11/98	101	92	7.7	7.42E-004	8.1	7.6	2.20	4.77E-005	116	81	13.1	3.8	60
05/12/98	100	91	7.7	7.57E-004	8.4	8.0	2.32	1.05E-004	125	86	16.3	4.7	60
05/13/98	103	93	8.3	7.46E-004	9.2	8.5	2.56	4.28E-005	133	84	17.7	3.9	60
05/14/98	100	91	7.6	7.50E-004	8.4	7.8	2.09	4.41E-005	117	82	12.1	4.2	60
05/15/98	102	93	8.3	7.69E-004	8.5	7.6	2.21	4.99E-005	117	84	12.7	4.6	60
05/16/98	103	94	8.0	7.14E-004	8.8	8.1	2.36	5.21E-005	122	83	14.9	4	60
05/17/98	104	94	8.6	7.46E-004	9.2	8.5	2.38	4.64E-005	125	83	15.1	4.1	60
05/18/98	102	93	8.2	7.53E-004	9.1	8.5	2.48	4.90E-005	119	80	13.4	3.5	53
05/19/98	105	96	9.0	7.50E-004	9.0	8.3	2.58	5.95E-005	123	85	15.6	4.7	60
05/20/98	100	91	7.3	7.15E-004	8.3	7.9	2.14	6.34E-005	130	87	16.6	4.7	60
05/21/98	104	95	8.7	7.52E-004	9.3	8.6	2.82	6.96E-005	127	81	17.7	4	60
05/22/98	103	95	8.7	7.69E-004	8.6	8.1	2.60	5.63E-005	125	89	16.6	5	60
05/23/98	107	99	9.7	7.74E-004	8.7	8.0	2.51	4.93E-005	130	90	17.1	5.3	60
05/24/98	107	97	9.4	7.61E-004	8.4	7.7	2.39	5.42E-005	124	85	14.4	4.7	60
05/25/98	104	95	9.1	7.87E-004	7.8	7.5	2.36	5.16E-005	123	90	15.5	5.2	60
05/26/98	104	95	8.9	7.72E-004	8.0	7.5	2.55	4.71E-005	131	86	18.6	4.9	60
05/27/98	107	97	10.1	8.12E-004	9.2	8.4	2.85	4.04E-005	129	89	20	5.5	60
05/28/98	108	99	10.2	7.79E-004	9.0	8.3	2.84	4.34E-005	128	90	17	5.4	60
05/29/98	107	97	9.8	7.81E-004	7.9	7.3	2.46	4.59E-005	134	92	18.4	6.1	60
05/30/98	105	95	9.4	8.01E-004	8.6	7.9	2.72	6.37E-005	131	83	19.7	4.6	60
05/31/98	105	97	9.1	7.67E-004	7.2	6.7	2.02	4.76E-005	125	94	14.6	6	60
06/01/98	107	97	9.6	7.73E-004	7.3	6.8	2.13	3.70E-005	122	92	14.9	6.1	60
06/02/98													0
06/03/98	110	99	10.4	7.72E-004	7.3	6.8	2.18	4.79E-005	126	92	16.7	6.4	60
06/04/98	110	101	10.6	7.80E-004	8.5	7.8	2.55	4.56E-005	136	93	19.6	6.3	60
06/05/98	106	97	9.3	7.74E-004	6.9	6.6	1.86	4.95E-005	125	92	15.4	5.9	60
06/06/98	107	98	10.0	7.97E-004	7.1	6.5	2.14	4.22E-005	126	93	16.8	6.1	60

Appendix D. Daily average size of YOY salmon captured at Woodbridge Dam - Traps 1 and 2: December 15, 1997 -- August 2, 1998.

Date	Avg TL, mm	Avg FL, mm	Avg Wt, g	Avg K	Std TL	Std FL	Std Wt	Std K	Max TL, mm	Min TL, mm	Max Wt, g	Min Wt, g	N
06/07/98	108	98	10.3	7.99E-004	7.9	7.2	2.47	4.78E-005	131	94	17.7	6.6	60
06/08/98	110	100	10.7	7.89E-004	7.3	6.9	2.39	5.55E-005	125	97	16.1	6.3	60
06/09/98	108	98	9.9	7.78E-004	7.7	7.2	2.67	4.06E-005	142	97	24.3	6.8	60
06/10/98	108	99	9.9	7.72E-004	6.3	5.9	1.78	4.79E-005	120	95	15	6.5	60
06/11/98	110	100	10.9	8.07E-004	6.0	5.5	1.94	4.60E-005	123	94	15.3	6.6	60
06/12/98	107	97	9.8	7.88E-004	6.3	5.6	1.73	4.23E-005	129	97	15.2	7	58
06/13/98	111	101	11.3	8.08E-004	7.5	6.9	2.68	5.80E-005	129	93	18.7	6.6	60
06/14/98	112	102	11.4	8.05E-004	6.2	5.8	2.03	3.89E-005	127	98	16.5	7.2	60
06/15/98	112	103	11.4	8.06E-004	8.1	7.4	2.49	4.68E-005	129	82	17.5	4.7	60
06/16/98	114	104	12.3	8.21E-004	8.1	6.9	2.66	5.32E-005	133	98	19.7	8.4	60
06/17/98	111	102	11.5	8.30E-004	7.4	6.6	2.37	3.46E-005	129	94	18.1	6.7	60
06/18/98	113	103	11.9	8.18E-004	6.9	6.0	2.29	3.60E-005	135	100	20.6	8	57
06/19/98	113	103	11.8	8.09E-004	8.0	7.2	2.71	3.68E-005	138	97	22.1	7.1	60
06/20/98	113	103	11.9	8.20E-004	5.5	5.0	1.72	4.12E-005	125	97	16.1	7.9	60
06/21/98	115	104	12.7	8.31E-004	8.6	8.1	2.89	6.60E-005	133	96	18.9	9.3	21
06/22/98	113	103	12.1	8.39E-004	6.1	5.5	1.95	4.00E-005	127	100	16.9	8.8	30
06/23/98	115	105	12.6	8.16E-004	7.2	6.4	2.34	4.90E-005	130	101	16.2	8.1	30
06/24/98	112	102	11.6	8.33E-004	8.3	8.5	2.33	5.17E-005	127	100	15.5	8.1	8
06/25/98	114	104	12.6	8.42E-004	5.3	4.9	2.09	4.94E-005	123	103	16.5	8.5	16
06/26/98	117	106	13.8	8.36E-004	13.6	13.2	5.62	4.00E-005	147	103	26.8	9.7	10
06/27/98	115	105	13.7	8.69E-004	10.9	10.2	4.32	5.67E-005	130	103	21.6	8.7	9
06/28/98	126	115	17.1	8.28E-004	14.0	13.0	6.79	3.58E-005	148	110	28.6	10.4	6
06/29/98	120	110	12.2	7.06E-004	0.0	0.0	0.00		120	120	12.2	12.2	1
06/30/98	124	113	16.7	8.59E-004	8.1	7.1	3.70	5.80E-005	134	115	20.8	11.9	5
07/01/98	117	107	14.2	8.78E-004	4.6	3.7	1.75	5.04E-005	122	109	17.1	11.9	11
07/02/98	121	110	14.7	8.25E-004	6.7	5.7	2.15	2.96E-005	131	114	18.1	12.3	7
07/03/98	119	108	15.0	8.88E-004	12.6	11.6	3.79	4.26E-005	131	97	18.7	8.8	6
07/04/98	120	109	14.3	8.36E-004	4.9	4.2	1.44	1.62E-005	122	115	15.2	13	3
07/05/98	108	99	10.6	8.41E-004	0.0	0.0	0.00		108	108	10.6	10.6	1

Appendix D. Daily average size of YOY salmon captured at Woodbridge Dam - Traps 1 and 2: December 15, 1997 -- August 2, 1998.

Date	Avg TL, mm	Avg FL, mm	Avg Wt, g	Avg K	Std TL	Std FL	Std Wt	Std K	Max TL, mm	Min TL, mm	Max Wt, g	Min Wt, g	N
07/06/98	132	124	20.7	9.00E-004	0.0	0.0	0.00		132	132	20.7	20.7	1
07/07/98	125	115	17.8	8.99E-004	12.9	10.4	4.69	4.08E-005	139	113	23.2	13.1	6
07/08/98	116	106	13.7	8.56E-004	10.2	9.6	3.74	1.51E-005	127	106	17.5	10.2	5
07/09/98	120	109	15.4	8.57E-004	19.9	18.0	7.82	3.99E-005	134	102	21.1	8.5	3
07/10/98	116	106	14.9	8.74E-004	35.2	31.6	11.28	2.77E-005	142	85	23.9	5.5	3
07/11/98	122	110	17.0	9.36E-004	0.0	0.0	0.00		122	122	17	17	1
07/12/98	116	105	13.4	8.58E-004	0.0	0.0	0.00		116	116	13.4	13.4	1
07/13/98	127	115	16.6	8.10E-004	0.0	0.0	0.00		127	127	16.6	16.6	1
07/14/98	132	120	19.6	8.52E-004	0.0	0.0	0.00		132	132	19.6	19.6	1
07/15/98	138	126	23.9	9.10E-004	9.0	9.0	7.10	4.70E-005	142	133	27.4	20.3	2
07/16/98	121	110	16.6	9.23E-004	10.5	8.6	4.69	2.33E-005	129	112	20.1	12.5	3
07/17/98													0
07/18/98													0
07/19/98													0
07/20/98													0
07/21/98													0
07/22/98													0
07/23/98	117	107	14.2	8.88E-004	11.0	10.0	5.00	3.21E-005	122	111	16.7	11.7	2
07/24/98													0
07/25/98													0
07/26/98													0
07/27/98													0
07/28/98	129	117	15.7	7.31E-004	0.0	0.0	0.00		129	129	15.7	15.7	1
07/29/98													0
07/30/98													0
07/31/98	146	135	22.0	7.07E-004	0.0	0.0	0.00		146	146	22	22	1
08/01/98	126	118	19.8	9.90E-004	0.0	0.0	0.00		126	126	19.8	19.8	1
08/02/98	134	122	22.1	9.18E-004	0.0	0.0	0.00		134	134	22.1	22.1	1

Appendix E. Daily environmental conditions at Woodbridge dam: December 15, 1997 -- August 2, 1998.

Date	Avg River Flow		Water Temp (F)		Secchi Depth, cm			Turbidity (NTUs)			Rainfall (in)			Baropress	Moonage	Sunrise	Sunset	
	River Flow	Canal Flow	WID	Avg	Max	Min	AM	PM	Avg	AM	PM	Avg	Camanche					Woodbridge
12/15/97	555	0	0	53.3	53.8	52.9	85.0	100.0	92.5	5.49	4.90	5.20	0.00	0.01	30.24	16	717	1646
12/16/97	549	0	0	53.7	54.3	53.2	100.0	110.0	105.0	4.56	--	4.56	0.30	0.00	30.24	17	718	1646
12/17/97	548	0	0	53.7	54.1	53.2	115.0	120.0	117.5	4.40	--	4.40	0.00	0.00	30.09	18	718	1646
12/18/97	550	0	0	54.0	54.7	53.6	--	120.0	120.0	--	3.54	3.54	0.02	0.00	29.88	19	719	1647
12/19/97	551	0	0	52.9	53.6	52.2	--	120.0	120.0	--	3.85	3.85	0.02	0.00	30.03	20	719	1647
12/20/97	550	0	0	52.3	53.1	51.8	--	120.0	120.0	--	3.45	3.45	0.00	0.00	29.97	21	720	1648
12/21/97	549	0	0	52.1	52.9	51.1	--	120.0	120.0	--	3.40	3.40	0.00	0.00	29.88	22	720	1648
12/22/97	555	0	0	50.3	50.9	49.6	--	120.0	120.0	--	4.87	4.87	0.00	0.00	29.94	23	721	1649
12/23/97	556	0	0	50.5	51.6	49.6	--	110.0	110.0	--	4.48	4.48	0.00	0.00	30.12	24	721	1649
12/24/97	557	0	0	50.5	51.4	49.8	120.0	--	120.0	4.59	--	4.59	0.00	0.00	30.00	25	722	1650
12/25/97	556	0	0	49.9	50.9	49.1	--	105.0	105.0	--	4.02	4.02	0.00	0.00	30.15	26	723	1651
12/26/97	552	0	0	49.9	50.9	49.3	110.0	--	110.0	3.05	--	3.05	0.00	0.00	30.39	27	723	1651
12/27/97	552	0	0	49.5	50.5	48.9	140.0	--	140.0	3.60	--	3.60	0.01	0.00	30.42	28	723	1652
12/28/97	554	0	0	49.7	50.9	48.9	130.0	--	130.0	3.68	--	3.68	0.00	0.00	30.30	29	723	1653
12/29/97	554	0	0	50.0	50.9	49.5	--	140.0	140.0	--	2.88	2.88	0.00	0.00	30.12	0	723	1653
12/30/97	554	0	0	50.2	51.3	49.5	--	125.0	125.0	--	4.23	4.23	0.00	0.00	30.00	1	724	1654
12/31/97	551	0	0	51.1	52.0	50.4	130.0	--	130.0	4.53	--	4.53	0.00	0.00	30.00	2	724	1655
01/01/98	572	0	0	51.1	51.6	50.7	140.0	--	140.0	4.52	--	4.52	0.00	0.00	29.85	3	724	1656
01/02/98	577	0	0	51.5	52.3	50.9	100.0	--	100.0	5.07	--	5.07	0.50	0.34	29.71	4	724	1656
01/03/98	554	0	0	52.0	52.7	51.6	140.0	--	140.0	5.70	--	5.70	0.06	0.11	29.74	5	724	1657
01/04/98	588	0	0	51.7	52.3	51.1	70.0	--	70.0	16.90	--	16.90	0.75	0.58	29.85	6	725	1658
01/05/98	571	0	0	50.3	50.9	49.6	70.0	--	70.0	7.94	--	7.94	0.16	0.00	30.15	7	725	1659
01/06/98	557	0	0	49.8	50.5	49.3	--	135.0	135.0	--	3.57	3.57	0.00	0.13	30.18	8	725	1700
01/07/98	554	0	0	51.0*	51.0*	51.0*	130.0	--	130.0	5.32	--	5.32	0.04	0.00	30.09	9	724	1701
01/08/98	557	0	0	51.5*	51.5*	51.5*	130.0	--	130.0	3.96	--	3.96	0.00	0.00	29.97	10	724	1702
01/09/98	569	0	0	50.5	50.7	50.2	100.0	--	100.0	5.13	--	5.13	0.03	0.44	29.77	11	724	1703
01/10/98	575	0	0	51.1	51.6	50.5	--	70.0	70.0	--	5.88	5.88	0.55	0.17	29.88	12	724	1704
01/11/98	561	0	0	51.5	51.8	51.1	--	90.0	90.0	--	4.67	4.67	0.22	0.29	30.03	13	724	1705
01/12/98	661	0	0	51.9	52.2	51.3	50.0	--	50.0	12.20	--	12.20	0.73	1.00	29.97	14	724	1706
01/13/98	647	0	0	50.8	51.3	50.4	40.0	--	40.0	37.30	--	37.30	0.56	0.02	30.18	15	724	1707
01/14/98	573	0	0	50.9	51.3	50.5	70.0	--	70.0	12.10	--	12.10	0.05	0.49	30.12	16	723	1708
01/15/98	630	0	0	50.9	51.4	50.5	70.0	--	70.0	--	--	--	0.90	0.32	30.00	17	723	1709
01/16/98	624	0	0	51.9	52.3	51.3	50.0	--	50.0	15.30	--	15.30	0.52	0.02	30.12	18	723	1710
01/17/98	544	0	0	52.8	54.0	52.0	85.0	--	85.0	7.52	--	7.52	0.03	0.00	30.15	19	722	1711
01/18/98	565	0	0	52.3	52.7	51.4	120.0	--	120.0	6.03	--	6.03	0.00	0.92	29.83	20	722	1712
01/19/98	730	0	0	51.0	51.4	50.5	40.0	--	40.0	24.90	--	24.90	0.92	0.08	29.94	21	721	1713
01/20/98	711	0	0	50.4	50.9	50.0	80.0	--	80.0	12.00	--	12.00	0.06	0.00	30.00	22	721	1714
01/21/98	697	0	0	50.1	50.7	49.8	100.0	--	100.0	6.81	--	6.81	0.00	0.00	30.09	23	720	1715
01/22/98	806	0	0	50.2	50.5	49.8	90.0	--	90.0	9.53	--	9.53	0.00	0.00	30.12	24	720	1716
01/23/98	857	0	0	50.6	50.7	50.2	90.0	--	90.0	7.81	--	7.81	0.00	0.00	30.06	25	718	1717
01/24/98	863	0	0	50.5	51.3	50.0	100.0	--	100.0	8.83	--	8.83	0.00	0.00	30.09	26	718	1718
01/25/98	864	0	0	50.5	50.9	50.2	100.0	--	100.0	10.50	--	10.50	0.00	0.00	30.09	27	717	1720
01/26/98	866	0	0	50.4	50.7	50.2	90.0	--	90.0	8.60	--	8.60	0.00	0.15	30.00	28	716	1721
01/27/98	876	0	0	50.9	51.6	50.5	80.0	--	80.0	9.98	--	9.98	0.06	0.09	30.00	0	716	1722
01/28/98	887	0	0	50.9	51.3	50.5	90.0	--	90.0	8.02	--	8.02	0.00	0.00	29.85	1	715	1723

Appendix E. Daily environmental conditions at Woodbridge dam: December 15, 1997 -- August 2, 1998.

Date	Avg River Flow		Water Temp (F)		Secchi Depth, cm		Turbidity (NTUs)		Rainfall (in)		Baropress	Moonage	Sunrise	Sunset		
	River Flow	Canal Flow	WID	Avg	Max	Min	AM	PM	Avg	PM					AM	PM
01/29/98	971	0	0	51.1	51.3	50.5	50.0	16.20	--	16.20	1.02	0.69	29.88	2	714	1724
01/30/98	961	0	0	50.7	51.1	50.2	70.0	11.40	--	11.40	0.07	0.00	29.91	3	713	1725
01/31/98	912	0	0	50.5	50.9	50.2	100.0	8.44	--	8.44	0.10	0.09	29.77	4	713	1726
02/01/98	927	0	0	50.4	50.5	50.2	90.0	9.23	--	9.23	0.00	0.45	29.74	5	712	1727
02/02/98	975	0	0	51.0	52.0	50.0	90.0	9.79	--	9.79	0.20	0.67	29.53	6	711	1728
02/03/98	1380	0	0	51.7	52.0	51.1	30.0	26.30	--	26.30	2.05	1.87	29.29	7	710	1730
02/04/98	1930	0	0	51.1	51.6	50.7	30.0	28.60	--	28.60	0.65	0.02	29.71	8	709	1731
02/05/98	2470	0	0	51.1	51.4	50.9	40.0	23.90	--	23.90	0.12	0.24	29.83	9	708	1732
02/06/98	2820	0	0	51.0	51.3	50.7	50.0	17.20	--	17.20	0.14	0.40	29.53	10	707	1733
02/07/98	2960	0	0	50.6	51.1	50.4	40.0	19.20	--	19.20	0.62	0.58	29.74	11	706	1734
02/08/98	2930	0	0	50.4	50.5	50.0	50.0	14.90	--	14.90	0.33	0.23	29.94	12	705	1737
02/09/98	2930	0	0	50.8	51.3	50.4	70.0	12.80	--	12.80	0.52	0.00	30.12	13	704	1738
02/10/98	3090	0	0	50.1	50.9	49.6	60.0	17.20	--	17.20	0.00	0.23	30.15	14	703	1739
02/11/98	3270	0	0	50.5	51.3	49.8	60.0	14.50	--	14.50	0.25	0.00	30.18	15	702	1740
02/12/98	3350	0	0	49.9	50.7	49.5	50.0	14.90	--	14.90	0.12	0.52	30.09	16	701	1741
02/13/98	3350	0	0	50.3	50.9	49.8	50.0	15.00	--	15.00	0.25	0.00	29.97	17	700	1743
02/14/98	3410	0	0	50.2	50.7	49.6	50.0	17.50	--	17.50	0.37	0.77	29.59	18	659	1744
02/15/98	3470	0	0	50.6	51.1	50.0	50.0	11.20	--	11.20	0.70	0.00	29.83	19	657	1745
02/16/98	3420	0	0	49.6	50.5	49.1	50.0	13.30	--	13.30	0.00	0.34	29.65	20	655	1746
02/17/98	3400	0	0	50.2	51.1	49.5	60.0	9.73	--	9.73	0.31	0.00	29.83	21	655	1747
02/18/98	3370	0	0	50.4	50.9	49.6	80.0	8.06	--	8.06	0.00	0.00	30.12	22	654	1748
02/19/98	3280	0	0	50.2	50.9	49.5	80.0	9.99	--	9.99	0.07	0.67	29.94	23	652	1749
02/20/98	3080	0	0	49.9	50.5	49.3	70.0	12.60	--	12.60	0.61	0.00	30.00	24	651	1750
02/21/98	3000	0	0	49.6	50.4	49.1	80.0	11.30	10.90	11.30	0.00	0.59	29.85	25	650	1751
02/22/98	3010	0	0	50.1	50.7	49.5	80.0	10.50	10.30	10.40	0.37	0.00	29.91	26	649	1752
02/23/98	2990	0	0	50.1	50.7	49.8	90.0	10.30	10.70	10.35	0.06	0.17	29.62	27	647	1753
02/24/98	2980	0	0	50.1	50.9	49.5	80.0	10.00	10.10	10.20	0.45	0.00	29.80	28	646	1754
02/25/98	2930	0	0	50.3	50.5	49.5	80.0	8.92	8.88	8.90	0.01	0.00	30.03	29	645	1755
02/26/98	2930	0	0	50.2	50.9	49.6	80.0	9.82	11.20	10.51	0.00	0.00	30.03	0	643	1756
02/27/98	2930	0	0	49.7	50.2	48.9	90.0	8.76	9.75	9.26	0.00	0.00	30.09	1	642	1757
02/28/98	2920	0	0	49.7	50.0	48.9	90.0	8.03	8.14	8.09	0.00	0.00	30.18	2	641	1758
03/01/98	2900	0	0	49.6	50.0	48.9	90.0	8.22	8.59	8.41	0.00	0.00	30.09	3	639	1759
03/02/98	2890	0	0	49.7	50.4	48.7	90.0	8.04	8.35	8.20	0.00	0.00	30.00	4	638	1800
03/03/98	2900	0	0	49.9	50.5	49.1	90.0	8.73	9.16	8.95	0.04	0.00	29.94	5	636	1801
03/04/98	2890	0	0	49.1	49.6	48.2	90.0	9.33	9.29	9.31	0.00	0.00	29.91	6	635	1802
03/05/98	2900	0	0	48.7	49.5	48.4	90.0	8.51	8.04	8.28	0.00	0.46	29.77	7	634	1803
03/06/98	2900	0	0	49.3	50.5	48.4	90.0	8.51	8.03	8.27	0.44	0.01	29.83	8	632	1804
03/07/98	2890	0	0	48.9	49.6	48.2	90.0	8.84	8.12	8.48	0.00	0.06	30.06	9	631	1805
03/08/98	2880	0	0	49.8	50.7	48.9	100.0	8.04	8.55	8.30	0.04	0.04	30.15	10	629	1806
03/09/98	2880	0	0	49.7	50.2	48.6	100.0	7.65	--	7.65	0.00	0.00	30.18	11	628	1807
03/10/98	2880	0	0	50.2	51.1	49.1	110.0	7.91	6.76	7.34	0.00	0.00	30.15	12	626	1808
03/11/98	2870	0	0	50.7	51.3	49.8	110.0	7.17	9.16	8.17	0.00	0.00	30.03	13	625	1809
03/12/98	2770	0	0	49.9	50.7	49.3	100.0	8.15	8.26	8.21	0.00	0.00	29.85	14	622	1810
03/13/98	2590	0	0	49.8	50.2	49.3	100.0	8.00	7.59	7.80	0.00	0.15	29.85	15	621	1811
03/14/98	2410	0	0	50.3	51.1	49.1	100.0	7.39	6.98	7.19	0.00	0.00	29.91	16	619	1812

Appendix E. Daily environmental conditions at Woodbridge dam: December 15, 1997 -- August 2, 1998.

Date	Avg River Flow		WID Canal Flow		Water Temp (F)			Secchi Depth, cm			Turbidity (NTUs)			Rainfall (in)			Baropress	Moonage	Sunrise	Sunset
	Avg	Canal Flow	Min	Max	Avg	AM	PM	Avg	AM	PM	Avg	Camanche	Woodbridge	AM	PM	Avg				
03/15/98	2350	0	51.0	51.6	50.0	100.0	130.0	115.0	7.32	8.07	7.70	0.00	0.00	29.97	17	618	1813			
03/16/98	2340	0	50.7	51.3	49.8	100.0	130.0	115.0	7.74	7.46	7.60	0.00	0.00	29.85	18	616	1814			
03/17/98	2330	0	50.6	51.4	49.3	110.0	110.0	110.0	7.24	7.09	7.17	0.00	0.00	29.83	19	615	1815			
03/18/98	2310	0	50.7	51.4	49.5	100.0	120.0	110.0	7.22	7.23	7.23	0.00	0.00	29.88	20	613	1816			
03/19/98	2170	0	50.7	51.4	49.5	100.0	110.0	110.0	7.06	6.35	6.71	0.00	0.00	29.91	21	612	1817			
03/20/98	1990	0	50.8	51.3	49.8	110.0	110.0	110.0	6.50	5.88	6.19	0.08	0.09	29.88	22	610	1819			
03/21/98	1810	0	50.7	51.3	50.4	110.0	110.0	110.0	7.14	7.10	7.12	0.15	0.04	30.00	23	609	1819			
03/22/98	1640	0	50.7	51.3	50.2	130.0	120.0	125.0	5.66	5.48	5.57	0.06	0.79	29.85	25	606	1820			
03/23/98	1620	0	50.7	51.6	50.0	140.0	140.0	130.0	6.28	5.35	5.82	1.28	0.22	29.71	26	604	1822			
03/24/98	1630	0	51.4	51.8	50.4	120.0	140.0	140.0	4.95	6.61	5.78	1.07	0.11	29.68	27	603	1823			
03/25/98	1630	0	51.4	52.0	50.7	140.0	140.0	140.0	6.15	5.81	5.98	0.00	0.00	29.83	28	601	1824			
03/26/98	1620	0	51.4	52.2	50.7	110.0	140.0	140.0	6.20	5.14	5.67	0.02	0.00	29.88	0	600	1825			
03/27/98	1580	0	51.1	51.8	50.4	140.0	140.0	140.0	4.47	3.85	4.16	0.00	0.01	29.62	1	558	1826			
03/28/98	1550	0	50.5	51.8	49.3	130.0	150.0	140.0	4.78	4.39	4.83	0.19	0.00	29.80	2	557	1827			
03/30/98	1300	0	51.1	52.2	50.4	150.0	160.0	155.0	4.78	4.93	4.86	0.00	0.00	29.94	3	555	1828			
03/31/98	1310	0	50.8	52.2	49.6	150.0	150.0	150.0	4.90	4.68	4.79	0.12	0.48	29.74	4	554	1829			
04/01/98	1290	0	50.2	51.6	49.3	150.0	150.0	150.0	4.78	4.03	4.41	0.18	0.00	29.80	5	551	1830			
04/02/98	1280	0	50.8	51.1	50.5	160.0	160.0	160.0	4.89	4.18	4.54	0.01	0.17	30.03	6	550	1831			
04/03/98	1310	0	50.6	51.1	50.4	150.0	140.0	145.0	4.58	5.34	4.96	0.50	0.43	29.94	7	548	1831			
04/04/98	1440	0	51.0	51.8	50.2	160.0	160.0	160.0	4.83	5.01	4.92	0.21	0.04	29.88	8	547	1832			
04/05/98	1540	0	51.7	52.7	50.7	150.0	160.0	155.0	5.02	4.60	4.81	0.11	0.00	29.88	9	645	1934			
04/06/98	1540	0	51.3	51.8	50.9	130.0	130.0	130.0	5.23	5.35	5.29	0.00	0.08	29.91	10	644	1935			
04/07/98	1540	0	51.7	52.9	50.7	150.0	160.0	155.0	4.82	4.40	4.61	0.17	0.00	30.06	11	642	1936			
04/08/98	1530	0	52.0	52.7	50.9	150.0	150.0	150.0	4.57	5.10	4.84	0.00	0.01	30.15	12	641	1937			
04/09/98	1530	0	52.6	53.2	52.0	140.0	150.0	145.0	5.20	4.81	5.01	0.02	0.00	30.06	13	639	1938			
04/10/98	1530	0	52.7	53.2	52.0	140.0	160.0	150.0	4.95	4.57	4.76	0.00	0.00	29.88	14	638	1939			
04/11/98	1540	0	51.7	52.2	51.3	130.0	140.0	135.0	4.87	4.73	4.80	0.01	0.47	29.71	15	636	1940			
04/12/98	1540	0	52.0	53.2	50.7	130.0	130.0	130.0	5.20	5.38	5.29	0.11	0.17	29.97	16	635	1941			
04/13/98	1550	0	52.4	53.1	51.6	140.0	160.0	150.0	4.96	3.77	4.37	0.33	0.28	29.94	17	633	1942			
04/14/98	1550	0	52.0	52.7	51.4	150.0	150.0	150.0	3.82	4.72	4.27	0.45	0.23	29.94	18	632	1942			
04/15/98	1380	5 Est.	52.4	53.4	51.4	140.0	140.0	140.0	3.78	4.44	4.11	0.04	0.01	30.03	19	631	1943			
04/16/98	1420	6.9	52.8	53.6	51.6	150.0	130.0	140.0	3.48	4.79	4.14	0.00	0.00	30.12	20	629	1944			
04/17/98	1510	0.41	53.4	54.1	52.9	150.0	140.0	145.0	3.16	4.11	3.63	0.00	0.00	30.15	21	628	1945			
04/18/98	1520	0	53.8	54.3	53.4	150.0	150.0	150.0	4.22	4.16	4.19	0.00	0.00	30.12	22	626	1946			
04/19/98	1520	0	54.1	54.9	53.6	150.0	160.0	155.0	3.89	4.02	3.96	0.00	0.00	30.03	23	625	1947			
04/20/98	1520	0.14	54.6	55.4	54.1	150.0	150.0	150.0	4.43	4.08	4.26	0.00	0.00	30.00	24	624	1948			
04/21/98	1520	7.7	54.5	55.0	53.8	140.0	160.0	150.0	3.01	3.30	3.16	0.00	0.01	29.88	25	622	1949			
04/22/98	1510	23	54.2	54.5	53.8	150.0	155.0	152.5	2.71	2.96	2.84	0.00	0.00	29.74	26	621	1950			
04/23/98	1510	24	53.4	54.0	52.7	150.0	150.0	150.0	3.58	3.53	3.56	0.00	0.05	29.85	27	620	1951			
04/24/98	1510	25	53.2	54.1	52.3	150.0	160.0	155.0	3.90	3.53	3.72	0.08	0.00	29.94	28	619	1952			
04/25/98	1510	25	53.2	54.1	52.3	160.0	170.0	165.0	3.32	3.65	3.49	0.14	0.00	30.00	29	617	1953			
04/26/98	1510	24	54.5*	55.0*	54.0*	160.0	165.0	162.5	3.34	3.12	3.23	0.00	0.01	30.00	0	616	1954			
04/27/98	1520	22	54.9	55.4	54.5	150.0	160.0	155.0	3.32	4.24	3.78	0.00	0.00	29.97	1	615	1954			
04/28/98	1520	21	55.0	55.6	54.5	150.0	150.0	150.0	3.68	3.25	3.47	0.00	0.00	29.88	2	614	1955			

Appendix E. Daily environmental conditions at Woodbridge dam: December 15, 1997 -- August 2, 1998.

Date	Avg River Flow		Water Temp (F)			Secchi Depth, cm			Turbidity (NTUs)			Rainfall (in)		Baropress	Moonage	Sunrise	Sunset
	River Flow	Canal Flow	Avg	Max	Min	AM	PM	Avg	AM	PM	Avg	Camanche	Woodbridge				
04/29/98	1510	18	56.3	57.9	55.0	150.0	170.0	160.0	3.00	2.80	2.90	0.00	0.01	29.83	3	612	1956
04/30/98	1510	18	57.3	57.7	56.8	160.0	160.0	160.0	2.99	3.26	3.13	0.00	0.00	29.80	4	611	1957
05/01/98	1520	19	56.5	57.0	55.8	170.0	160.0	165.0	3.70	3.36	3.53	0.00	0.18	29.80	5	610	1958
05/02/98	1530	18	56.1	56.7	55.8	150.0	130.0	140.0	3.49	3.92	3.71	0.39	0.68	29.83	6	609	1959
05/03/98	1530	18	56.4	57.2	55.8	140.0	140.0	140.0	3.60	3.35	3.48	0.84	0.07	29.91	7	608	2000
05/04/98	1520	28	57.0	57.6	56.5	BROKEN			3.80	3.33	3.57	0.12	0.04	29.85	8	605	2001
05/05/98	1530	33	56.2	56.8	55.4	140.0	130.0	135.0	2.59	2.64	2.62	0.15	0.19	29.80	9	604	2002
05/06/98	1560	30	55.4	55.6	55.2	150.0	130.0	140.0	3.32	2.89	3.11	0.18	0.34	29.94	10	602	2003
05/07/98	1650	32	55.6	56.5	55.0	130.0	130.0	130.0	4.00	4.27	4.14	0.02	0.00	29.94	11	601	2004
05/08/98	1690	29	55.7	56.1	55.2	130.0	140.0	135.0	3.28	3.25	3.27	0.00	0.00	29.91	12	600	2004
05/09/98	1700	24	55.5	56.7	54.5	130.0	130.0	130.0	--	--	--	0.00	0.36	29.91	13	559	2005
05/10/98	1700	23	55.9	56.8	55.2	130.0	130.0	130.0	4.92	3.20	4.06	0.02	0.01	29.97	14	558	2006
05/11/98	1700	22	55.4	56.3	54.3	120.0	130.0	125.0	3.61	3.83	3.72	0.00	0.12	29.85	15	557	2007
05/12/98	1720	34	54.3	54.5	54.1	90.0	90.0	90.0	3.82	4.08	3.95	0.66	0.49	29.62	16	556	2008
05/13/98	1630	50	54.6	55.4	54.0	120.0	110.0	115.0	6.41	3.71	5.06	0.92	0.11	29.83	17	556	2009
05/14/98	1660	68	55.2	55.6	54.9	180.0	130.0	155.0	2.67	2.82	2.75	0.01	0.00	30.03	18	555	2010
05/15/98	1650	79	56.0	56.8	55.4	160.0	130.0	145.0	2.77	3.17	2.97	0.00	0.00	30.03	19	554	2012
05/16/98	1660	81	56.2	56.5	55.4	120.0	120.0	120.0	3.78	2.90	3.34	0.00	0.00	29.97	20	553	2013
05/17/98	1650	84	55.7	56.8	54.7	120.0	130.0	125.0	4.02	3.79	3.91	0.00	0.02	30.06	21	552	2013
05/18/98	1650	83	56.7	57.4	56.3	150.0	150.0	150.0	2.59	2.89	2.74	0.00	0.00	29.91	22	551	2014
05/19/98	1650	83	57.2	57.7	56.5	160.0	180.0	170.0	3.32	3.18	3.25	0.00	0.00	29.94	23	551	2015
05/20/98	1650	82	56.9	57.4	56.5	210.0	190.0	200.0	2.93	3.56	3.25	0.00	0.01	30.00	24	550	2016
05/21/98	1640	81	57.4	58.3	56.7	150.0	150.0	150.0	3.48	3.60	3.54	0.00	0.01	30.03	25	549	2017
05/22/98	1640	80	57.7	58.8	56.8	210.0	170.0	190.0	3.21	4.42	3.82	0.00	0.01	29.94	26	549	2018
05/23/98	1640	80	57.9	58.5	57.6	170.0	170.0	170.0	2.72	3.50	3.11	0.00	0.01	29.94	27	548	2018
05/24/98	1630	81	58.2	58.8	57.7	180.0	180.0	180.0	2.89	3.08	2.99	0.00	0.01	29.97	28	547	2019
05/25/98	1630	78	58.3	58.6	57.7	180.0	180.0	180.0	3.19	3.33	3.26	0.19	0.02	29.88	0	547	2020
05/26/98	1650	79	56.8	57.6	55.8	BROKEN			2.60	3.11	2.86	0.00	0.17	29.88	1	547	2021
05/27/98	1770	81	56.0	56.5	55.8	150.0	150.0	150.0	3.00	3.23	3.12	0.13	0.02	29.91	2	546	2021
05/28/98	1840	81	56.1	56.5	55.6	150.0	130.0	140.0	3.70	3.83	3.77	0.00	0.13	29.88	3	545	2022
05/29/98	1840	80	56.1	57.2	55.0	90.0	90.0	90.0	4.82	4.68	4.75	1.37	0.12	30.06	4	545	2023
05/30/98	1820	80	57.5	58.5	56.5	100.0	120.0	110.0	4.63	4.14	4.39	0.00	0.10	29.97	5	544	2024
05/31/98	1820	80	58.6	59.4	58.1	120.0	110.0	115.0	4.24	4.19	4.22	0.00	0.06	29.94	6	544	2025
06/01/98	1820	79	58.8	59.5	58.3	140.0	140.0	140.0	3.37	3.51	3.44	0.00	0.10	29.94	7	543	2025
06/02/98	1820	78	58.6	59.2	58.1	NO SAMPLING			NO SAMPLING	NO SAMPLING	0.00	0.00	0.07	29.91	8	543	2026
06/03/98	1820	82	58.1	58.5	57.6	150.0	120.0	135.0	4.16	4.00	4.08	0.00	0.00	29.91	9	543	2027
06/04/98	1810	84	58.0	59.4	57.0	150.0	150.0	150.0	2.48	3.07	2.78	0.00	0.00	29.94	10	542	2027
06/05/98	1820	84	58.8	59.9	57.9	110.0	190.0	150.0	3.44	3.80	3.62	0.00	0.00	29.91	11	542	2027
06/06/98	1810	83	59.0	59.9	58.1	150.0	150.0	150.0	3.88	4.83	4.36	0.00	0.08	29.83	12	542	2028
06/07/98	1820	83	56.3	56.8	57.4	120.0	120.0	120.0	2.33	2.72	2.53	0.14	0.05	29.88	13	542	2029
06/08/98	1810	83	58.2	59.5	57.2	160.0	150.0	155.0	2.66	3.12	2.89	0.01	0.01	29.85	14	542	2029
06/09/98	1810	87	59.2	60.8	57.9	130.0	150.0	140.0	3.72	2.96	3.34	0.00	0.00	29.85	15	542	2030
06/10/98	1800	88	59.1	59.4	58.5	150.0	150.0	150.0	4.34	4.08	4.21	0.00	0.00	29.80	16	541	2030
06/11/98	1810	88	58.2	58.6	57.9	140.0	130.0	135.0	3.25	3.72	3.49	0.00	0.00	29.77	17	541	2031
06/12/98	1790	95 Est.	58.8	60.4	57.4	160.0	150.0	155.0	2.43	3.34	2.89	0.00	0.00	29.85	18	541	2031

Appendix E. Daily environmental conditions at Woodbridge dam: December 15, 1997 -- August 2, 1998.

Date	Avg River Flow		WID Canal Flow	Water Temp (F)			Secchi Depth, cm			Turbidity (NTUs)			Rainfall (in)		Baropress	Moonage	Sunrise	Sunset
	River Flow	Avg		Max	Min	AM	PM	Avg	AM	PM	Avg	Cananche	Woodbridge					
06/13/98	1800	59.8	61.0	59.0	150.0	150.0	3.42	3.94	3.68	0.00	0.00	30.06	19	541	2031			
06/14/98	1800	60.5	61.5	59.5	130.0	170.0	2.68	1.69	2.19	0.00	0.00	29.97	20	541	2032			
06/15/98	1780	60.9	61.7	60.3	160.0	150.0	1.79	2.66	2.23	0.00	0.00	29.80	21	541	2032			
06/16/98	1770	60.8	61.3	60.4	150.0	150.0	3.40	1.74	2.57	0.00	0.00	29.65	22	541	2033			
06/17/98	1750	60.1	60.4	59.5	130.0	160.0	2.02	3.29	2.66	0.00	0.00	29.80	23	541	2033			
06/18/98	1750	60.7	61.7	59.9	160.0	150.0	2.77	3.54	3.16	0.00	0.00	29.85	24	541	2033			
06/19/98	1740	60.5	61.0	60.3	180.0	180.0	2.74	2.47	2.61	0.00	0.00	29.83	25	542	2034			
06/20/98	1870	60.0	60.6	59.4	200.0	210.0	2.22	3.36	2.79	0.00	0.00	29.83	26	542	2034			
06/21/98	1900	59.8	60.4	59.2	200.0	--	--	2.94	2.94	2.94	0.00	0.00	29.85	27	542	2034		
06/22/98	1950	59.8	60.4	59.2	170.0	190.0	2.04	2.42	2.23	0.00	0.00	29.88	28	542	2034			
06/23/98	2380	59.5	60.3	58.5	140.0	150.0	3.00	4.96	3.98	0.00	0.00	29.83	0	542	2034			
06/24/98	2550	59.6	60.3	58.8	160.0	150.0	4.69	3.47	4.08	0.00	0.00	29.80	1	543	2035			
06/25/98	2590	59.7	60.4	59.0	140.0	150.0	3.17	4.06	3.62	0.00	0.00	29.85	2	543	2035			
06/26/98	2720	59.3	59.9	58.5	160.0	150.0	4.15	5.25	4.70	0.00	0.00	29.91	3	543	2035			
06/27/98	3010	59.7	60.6	58.8	150.0	150.0	4.63	4.24	4.44	0.00	0.00	29.83	4	544	2035			
06/28/98	3130	59.7	60.4	58.8	130.0	140.0	5.00	5.90	5.45	0.00	0.00	29.85	5	544	2035			
06/29/98	3150	59.5	60.3	58.5	160.0	100.0	3.70	7.57	5.64	0.00	0.00	29.88	6	545	2035			
06/30/98	3170	59.4	60.3	58.5	80.0	110.0	4.83	5.26	5.05	0.00	0.00	29.91	7	545	2035			
07/01/98	3180	59.5	60.4	58.6	100.0	90.0	4.10	6.83	5.47	0.00	0.00	29.85	8	545	2034			
07/02/98	3190	59.5	60.4	58.6	130.0	130.0	5.76	5.61	5.69	0.00	0.00	29.80	9	546	2034			
07/03/98	3190	59.6	60.6	58.6	120.0	140.0	3.49	5.76	4.63	0.00	0.00	29.77	10	546	2034			
07/04/98	3180	59.8	60.6	58.8	110.0	110.0	3.23	5.82	4.53	0.00	0.00	29.77	11	547	2034			
07/05/98	3180	59.9	60.8	59.0	120.0	160.0	4.73	5.57	5.15	0.00	0.00	29.80	12	547	2034			
07/06/98	3190	59.9	60.8	59.0	180.0	150.0	4.53	3.98	4.26	0.00	0.00	29.88	13	548	2034			
07/07/98	3170	60.0	60.8	59.0	180.0	140.0	4.46	7.30	5.88	0.00	0.00	29.88	14	549	2033			
07/08/98	3150	60.0	60.8	59.0	130.0	170.0	3.51	4.10	3.81	0.00	0.00	29.83	15	549	2033			
07/09/98	3140	59.8	60.6	58.8	180.0	160.0	2.81	3.71	3.26	0.00	0.00	29.80	16	550	2033			
07/10/98	3070	59.7	60.6	58.6	180.0	180.0	4.58	3.99	4.29	0.00	0.00	29.88	17	550	2032			
07/11/98	2820	59.9	60.8	59.0	190.0	150.0	3.68	4.39	4.04	0.00	0.00	29.94	18	551	2032			
07/12/98	2760	60.2	61.2	58.2	140.0	160.0	2.25	3.79	3.02	0.00	0.00	29.85	19	552	2032			
07/13/98	2750	60.4	61.2	59.4	170.0	200.0	2.36	2.68	2.52	0.00	0.00	29.83	20	552	2031			
07/14/98	2680	60.4	61.3	59.2	180.0	--	3.06	3.14	3.10	0.00	0.00	29.85	21	553	2031			
07/15/98	2430	60.9	61.7	59.9	150.0	160.0	3.68	3.11	3.40	0.00	0.00	29.83	22	554	2030			
07/16/98	2210	61.0	61.7	59.9	160.0	170.0	3.81	4.17	3.99	0.00	0.00	29.77	23	555	2030			
07/17/98	2180	61.1	61.9	60.3	160.0	150.0	3.63	4.16	3.90	0.00	0.00	29.77	24	555	2029			
07/18/98	2160	61.3	62.1	60.4	170.0	180.0	3.27	3.05	3.17	0.00	0.00	29.71	25	556	2028			
07/19/98	2160	61.5	62.1	60.6	180.0	170.0	3.78	4.07	3.93	0.00	0.00	29.74	26	557	2028			
07/20/98	2160	61.3	61.9	60.4	160.0	180.0	3.28	3.56	3.42	0.00	0.00	29.80	27	557	2027			
07/21/98	2150	61.1	61.7	59.9	140.0	190.0	2.71	2.96	2.84	0.00	0.00	29.83	28	558	2027			
07/22/98	2150	60.6	61.3	59.7	170.0	160.0	3.10	3.53	3.32	0.00	0.00	29.83	29	559	2026			
07/23/98	2160	60.6	61.5	59.9	160.0	160.0	3.45	3.36	3.41	0.00	0.00	29.83	0	600	2025			
07/24/98	2140	60.9	61.5	60.3	150.0	150.0	3.05	3.57	3.31	0.00	0.00	29.88	1	600	2024			
07/25/98	2140	61.3	62.1	60.4	160.0	160.0	3.46	4.16	3.81	0.00	0.00	29.88	2	601	2024			
07/26/98	2130	61.7	62.6	61.0	Under Repair	Under Repair	3.94	3.59	3.77	0.00	0.00	29.88	3	602	2022			
07/27/98	2140	61.7	62.6	61.0	170.0	180.0	2.65	2.75	2.70	0.00	0.00	29.85	4	603	2021			

Appendix E. Daily environmental conditions at Woodbridge dam: December 15, 1997 -- August 2, 1998.

Date	Avg River Flow		WID Canal Flow	Water Temp (F)			Secchi Depth, cm			Turbidity (NTUs)			Rainfall (in)		Baropress	Moonage	Sunrise	Sunset
	River Flow	Avg		Max	Min	AM	PM	Avg	AM	PM	Avg	AM	PM	Camanche				
07/28/98	2130	61.6	62.1	60.8	170.0	170.0	170.0	170.0	170.0	2.24	6.57	4.41	0.00	0.00	29.83	5	604	2020
07/29/98	2140	61.4	61.9	60.6	170.0	180.0	175.0	170.0	180.0	2.96	2.71	2.84	0.00	0.00	29.83	6	605	2019
07/30/98	2140	61.2	61.7	60.6	170.0	180.0	175.0	170.0	180.0	2.77	2.68	2.73	0.00	0.00	29.85	7	605	2018
07/31/98	2010	61.2	61.9	60.4	180.0	180.0	180.0	180.0	180.0	3.21	3.98	3.60	0.00	0.00	29.91	8	606	2017
08/01/98	1730	62.3	63.0	61.9	160.0	170.0	165.0	160.0	170.0	2.72	3.44	3.08	0.00	0.00	29.91	9	607	816
08/02/98	1700	61.9	62.8	61.0	160.0	180.0	170.0	160.0	180.0	3.49	3.68	3.59	0.00	0.00	29.91	10	608	815

-- Indicates that a reading was not taken for the day.

Mokelumne River flow data from U.S.G.S. gaging station #11325500 at Woodbridge, CA. (operated by EBMUD)

Water temperatures were recorded hourly with a Ryan TM2000 submersible thermometer installed in pool #15 of the high-stage fishway or pool #6a of low-stage fishway.

Average temperature on these dates (*) are computed from a morning and an afternoon "grab sample" hand held thermometer measurements.

Secchi depth measured twice daily in pool #9a of low-stage fishway or from screw trap platform located about mid-channel below Woodbridge Dam.

Rainfall measured by National Weather Service station at Camanche Reservoir N., San Joaquin Co., CA and by EBMUD approximately 0.5 miles downstream from WIDD.

Baropressure measured (mm Hg) at 15 minute intervals and average daily value computed from a Campbell Scientific Instruments meteorological datalogger (w/Vaisala PTA 427A pressure transducer) deployed near Woodbridge, CA.

Lunar and solar data compiled from tables in the Old Farmer's Almanac, 1997 and 1998 editions, Yankee Publishing, Dublin, NH.

Appendix F. Delta outflow (in cfs): December 1997 --- July 1998.

December 1997

Date	Sacramento River At Freeport	Sacramento Treatment Plant	San Joaquin River Near Vernalis	Tracy Pump	Contra Costa Pump	Clifton Court Forebay Inflow	Byron Bethany Irrigation District	Delta Outflow Index
1	23,858	217	2,184	4,084	118	6,672	0	22,187
2	29,448	217	2,050	3,981	116	6,672	0	17,823
3	27,497	217	1,976	4,204	114	6,668	0	22,709
4	27,066	217	2,045	4,050	116	6,256	0	21,160
5	21,850	217	2,146	4,053	134	6,664	0	20,569
6	20,165	217	2,281	4,096	148	6,670	0	13,843
7	20,998	217	2,250	4,061	115	6,373	0	14,130
8	25,410	217	2,303	4,036	80	5,930	0	19,438
9	29,412	217	2,423	4,061	83	5,959	0	24,158
10	30,706	217	2,420	4,084	76	6,407	0	26,741
11	27,766	217	2,371	4,084	80	6,673	0	25,724
12	24,370	217	2,272	4,058	92	6,637	0	21,309
13	21,606	217	2,219	4,108	98	6,677	0	14,488
14	20,201	217	2,151	4,062	91	6,665	0	11,705
15	20,905	217	2,114	4,083	100	7,388	0	14,828
16	23,866	217	2,035	4,136	91	7,382	0	15,653
17	27,584	217	2,014	4,168	88	7,351	0	18,392
18	25,982	217	1,999	4,039	94	7,242	0	22,309
19	24,141	217	1,963	4,026	90	7,331	0	20,676
20	23,848	217	1,915	4,030	85	7,069	0	13,782
21	22,810	217	1,864	4,038	86	7,025	0	13,487
22	21,081	217	1,823	4,012	90	5,892	0	13,533
23	18,940	217	1,822	4,114	84	6,357	0	11,241
24	17,871	217	1,786	4,089	88	7,068	0	8,400
25	17,112	217	1,751	4,033	86	7,276	0	7,191
26	16,458	218	1,742	4,046	85	7,275	0	6,378
27	16,090	220	1,719	4,002	87	7,235	0	5,842
28	15,630	221	1,709	4,039	90	7,235	0	5,397
29	15,223	223	1,709	4,132	96	7,241	0	4,875
30	14,910	224	1,709	4,151	93	7,236	0	4,508
31	14,734	226	1,681	4,151	93	7,233	0	4,241
AVERAGE	22,179	218	2,009	4,074	96	6,836	0	14,818

Appendix F. Delta outflow (in cfs): December 1997 -- July 1998.

January 1998

Date	Sacramento River At Freeport	Sacramento Treatment Plant	San Joaquin River Near Vernalis	Tracy Pump	Contra Costa Pump	Clifton Court Forebay Inflow	Byron-Bethany Irrigation District	Delta Outflow Index
1	14,473	227	1,650	4,082	113	7,224	0	4,216
2	14,480	227	1,661	4,091	118	7,217	0	3,967
3	15,736	227	1,682	4,039	122	7,214	0	5,735
4	18,937	227	1,712	4,084	124	6,744	0	7,557
5	25,278	227	1,803	4,109	124	6,203	0	15,327
6	28,048	227	1,934	4,051	126	6,046	0	21,555
7	26,396	227	1,929	4,087	129	6,721	0	24,164
8	23,940	227	1,847	4,092	124	7,068	0	20,678
9	24,344	227	1,790	4,184	125	7,250	0	17,834
10	24,650	227	1,844	4,105	119	7,246	0	17,350
11	25,484	227	1,995	4,037	126	7,292	0	19,158
12	34,613	227	2,351	4,085	119	7,340	0	21,026
13	53,559	227	3,739	4,062	116	7,465	0	43,466
14	58,512	227	6,178	3,897	115	77	0	67,386
15	63,761	227	5,338	3,841	115	76	0	72,803
16	71,709	227	6,457	3,826	96	74	0	89,560
17	73,657	227	9,461	3,836	76	70	0	132,839
18	77,815	227	9,569	3,824	83	76	0	144,416
19	79,369	227	9,505	3,827	77	70	0	156,695
20	77,401	227	10,238	3,828	72	75	0	163,357
21	75,286	227	10,227	3,565	74	74	0	157,933
22	73,577	227	9,766	3,532	80	76	0	153,916
23	71,751	227	9,248	3,829	79	76	0	142,980
24	70,258	227	8,642	3,831	77	76	0	125,444
25	68,824	227	8,026	3,816	75	76	0	115,817
26	67,849	229	7,633	3,831	74	77	0	107,740
27	67,563	230	7,353	3,841	67	78	0	101,755
28	67,748	232	7,147	4,199	70	1,493	0	101,781
29	69,458	233	7,090	4,080	74	1,494	0	107,775
30	71,184	235	7,446	4,142	83	2,000	0	126,611
31	70,723	236	9,022	3,870	73	1,993	0	139,692
AVERAGE	51,819	228	5,622	3,952	98	3,196	0	78,404

Appendix F. Delta outflow (in cfs): December 1997 -- July 1998.

February 1998

Date	Sacramento River At Freeport	Sacramento Treatment Plant	San Joaquin River Near Vernalis	Tracy Pump	Contra Costa Pump	Clifton Court Forebay Inflow	Byron-Bethany Irrigation District	Delta Outflow Index
1	70,070	238	10,089	3,724	74	1,994	0	138,463
2	71,906	238	11,063	3,609	57	2,548	0	137,992
3	84,363	238	13,178	2,092	52	1,580	0	154,456
4	94,129	238	16,914	2,361	59	437	0	230,895
5	90,263	238	19,540	2,805	85	0	0	269,257
6	86,144	238	20,726	2,812	75	0	0	293,494
7	84,373	238	22,278	2,705	60	0	0	307,650
8	86,766	238	25,765	2,585	62	0	0	312,949
9	84,055	238	29,519	3,302	62	0	0	318,094
10	81,454	238	32,094	3,610	71	0	0	315,863
11	79,671	238	33,467	3,561	71	0	0	302,755
12	78,105	238	34,280	3,627	76	0	0	279,460
13	77,977	238	35,036	3,626	83	0	0	258,287
14	80,377	238	34,511	3,632	83	0	0	244,399
15	86,688	238	34,061	3,619	92	0	0	248,611
16	86,146	238	33,548	3,616	67	0	0	258,522
17	84,717	238	32,835	3,439	69	0	0	253,452
18	82,943	238	32,204	3,509	59	0	0	244,130
19	80,945	238	32,402	3,774	68	0	0	229,891
20	80,986	238	32,364	3,880	72	0	0	234,420
21	79,141	238	31,830	3,730	59	0	0	225,713
22	80,708	238	31,657	3,052	78	0	0	226,940
23	81,112	238	31,258	3,518	71	0	0	242,803
24	79,966	238	30,908	2,487	70	0	0	246,987
25	78,266	238	30,557	1,158	75	0	0	235,801
26	77,169	238	31,061	771	75	0	0	225,100
27	75,943	238	30,987	768	90	0	0	212,246
28	74,446	238	31,207	1,382	84	0	0	199,999
AVERAGE	81,387	238	28,043	2,956	71	234	0	244,594

Appendix F. Delta outflow (in cfs): December 1997 -- July 1998.

March 1998

Date	Sacramento River At Freeport	Sacramento Treatment Plant	San Joaquin River Near Vernalis	Tracy Pump	Contra Costa Pump	Clifton Court Forebay Inflow	Byron-Bethany Irrigation District	Delta Outflow Index
1	72,986	236	30,770	1,688	261	0	0	186,432
2	71,358	234	29,357	1,270	98	0	0	173,955
3	70,360	232	27,881	764	128	0	0	161,090
4	69,712	231	26,406	1,407	140	0	0	152,671
5	68,951	229	24,926	1,789	258	0	0	145,415
6	68,968	227	23,636	1,792	279	0	0	136,734
7	68,062	225	22,741	1,786	206	0	0	129,260
8	66,867	225	21,480	1,780	202	0	0	119,962
9	65,706	225	20,495	1,749	99	0	0	109,692
10	64,581	225	20,084	1,708	220	0	0	101,263
11	62,602	225	19,636	1,735	288	0	0	92,289
12	59,781	225	19,133	1,827	285	0	0	87,665
13	56,908	225	18,692	1,909	255	0	0	84,017
14	54,116	225	18,162	1,901	257	0	0	80,509
15	52,165	225	17,622	1,895	254	0	0	77,056
16	51,179	225	17,048	1,892	255	0	0	74,312
17	49,857	225	16,367	1,898	249	0	0	72,687
18	47,644	225	15,405	1,892	256	0	0	70,612
19	47,696	225	14,343	1,890	220	0	0	67,413
20	50,524	225	13,979	1,889	195	0	0	66,312
21	51,775	225	14,566	1,894	207	0	0	68,411
22	54,334	225	14,676	1,893	124	0	0	70,444
23	58,408	225	14,313	1,906	80	0	0	73,490
24	64,715	225	14,069	2,977	79	0	0	80,552
25	72,186	225	13,978	3,532	83	0	0	98,770
26	76,731	225	14,950	3,546	82	0	0	145,314
27	77,746	225	15,965	2,984	84	0	0	162,906
28	77,841	225	16,934	2,690	74	0	0	172,940
29	76,734	225	19,019	2,676	81	0	0	172,258
30	75,120	225	21,556	2,692	71	0	0	167,181
31	73,433	225	22,536	2,675	79	0	0	157,853
AVERAGE	63,840	226	19,378	2,062	176	0	0	114,821

Appendix F. Delta outflow (in cfs): December 1997 -- July 1998.

April 1998

Date	Sacramento River At Freeport	Sacramento Treatment Plant	San Joaquin River Near Vernalis	Tracy Pump	Contra Costa Pump	Clifton Court Forebay Inflow	Byron-Bethany Irrigation District	Delta Outflow Index
1	72,285	222	22,325	1,748	148	0	0	150,883
2	70,877	218	21,784	3,493	199	0	0	133,681
3	70,631	215	21,210	2,871	199	0	0	120,337
4	70,760	211	21,059	1,074	184	0	0	122,514
5	70,160	208	21,115	731	165	0	0	122,900
6	69,450	204	21,054	764	193	0	0	115,025
7	69,053	201	21,063	1,369	194	0	0	110,318
8	68,848	201	21,442	1,713	217	0	0	106,945
9	68,651	201	22,098	1,004	241	0	0	104,254
10	67,940	201	22,629	738	200	0	0	103,281
11	66,861	201	22,719	766	249	0	0	98,530
12	65,086	201	22,870	762	205	0	0	94,671
13	63,237	201	23,529	761	240	0	0	92,168
14	61,570	201	24,325	758	258	0	0	94,164
15	59,488	201	24,763	761	247	0	0	94,256
16	56,714	201	24,825	609	268	0	0	93,073
17	53,918	201	24,868	1,001	252	0	0	88,343
18	50,558	201	24,656	847	253	0	0	83,762
19	47,402	201	24,228	847	249	0	0	78,224
20	45,521	201	23,753	1,525	248	0	0	73,656
21	44,973	201	22,953	1,919	209	0	0	70,481
22	44,133	201	21,404	1,919	172	0	27	68,533
23	43,959	201	20,305	1,921	252	0	13	66,006
24	44,977	201	20,005	1,942	250	0	10	64,890
25	46,742	200	19,635	1,909	249	0	20	65,873
26	47,660	200	19,486	1,916	249	504	20	66,622
27	47,507	199	19,210	1,924	252	16	10	67,627
28	48,028	199	18,921	1,919	256	0	10	66,644
29	47,361	198	18,639	1,924	281	0	26	66,590
30	46,228	198	18,351	1,924	294	0	20	65,757
AVERAGE	57686	203	21841	1445	229	17	5	91667

Appendix F. Delta outflow (in cfs): December 1997 -- July 1998.

May 1998

Date	Sacramento River At Freport	Sacramento Treatment Plant	San Joaquin River Near Vernalis	Tracy Pump	Contra Costa Pump	Clifton Court Forebay Inflow	Byron-Bethany Irrigation District	Delta Outflow Index
1	45,637	197	18,012	1,927	309	0	33	64,652
2	46,413	197	17,817	1,925	308	500	33	63,413
3	47,297	197	17,636	1,926	297	0	32	67,028
4	48,560	197	17,184	1,921	278	0	33	68,869
5	49,316	197	16,505	1,923	225	0	17	69,548
6	49,554	197	16,215	1,922	202	0	0	71,209
7	49,734	197	16,278	1,920	181	456	0	71,749
8	48,851	197	16,323	1,919	202	205	0	70,131
9	46,781	197	16,437	1,919	253	0	0	69,009
10	44,906	197	16,482	1,915	256	0	0	66,728
11	44,392	197	16,431	1,925	252	492	0	62,774
12	44,508	197	16,505	1,919	258	497	0	60,981
13	46,031	197	17,458	1,920	270	476	0	64,238
14	49,050	197	17,787	1,874	285	455	0	68,009
15	50,114	197	17,739	1,838	267	496	0	70,831
16	49,847	197	17,829	2,591	254	546	0	70,618
17	49,749	197	17,989	2,885	235	547	0	69,565
18	50,965	197	18,252	2,880	280	540	0	67,006
19	51,748	197	18,824	2,883	307	594	27	67,277
20	50,672	197	19,261	2,850	304	800	28	68,195
21	47,774	197	19,405	2,854	309	891	24	67,411
22	45,687	197	19,430	2,857	312	2,494	44	62,897
23	43,485	197	19,349	2,850	307	2,499	38	60,698
24	42,261	197	19,203	3,388	293	2,492	0	57,749
25	42,124	197	18,945	3,649	289	2,494	0	55,993
26	43,025	196	18,478	3,117	316	2,492	27	56,305
27	45,706	196	18,167	2,302	326	2,495	27	57,677
28	49,133	195	17,985	2,062	331	2,690	51	59,996
29	52,241	195	18,319	2,040	315	1,096	29	70,499
30	57,016	194	18,356	2,009	313	1,098	30	77,654
31	63,173	194	18,245	2,011	298	858	0	81,401
AVERAGE	48,250	197	17,834	2,320	278	910	15	66,455

Appendix F. Delta outflow (in cfs): December 1997 -- July 1998.

June 1998

Date	Sacramento River At Freeport	Sacramento Treatment Plant	San Joaquin River Near Vernalis	Tracy Pump	Contra Costa Pump	Clifton Court Forebay Inflow	Byron-Bethany Irrigation District	Delta Outflow Index
1	68,932	193	18,284	2,010	277	799	41	91,810
2	69,762	193	18,217	2,007	225	618	15	120,756
3	68,967	193	17,904	2,004	257	880	67	115,752
4	67,181	193	17,521	2,007	218	1,173	53	103,097
5	65,520	193	17,167	2,010	236	1,319	82	92,299
6	64,578	193	16,741	2,012	293	2,198	50	85,299
7	64,057	193	16,518	2,011	318	1,293	50	82,384
8	63,488	193	16,397	2,643	301	1,395	83	79,705
9	62,616	193	16,081	2,891	307	1,396	92	77,340
10	60,433	193	15,812	2,899	199	1,098	63	75,919
11	58,434	193	15,992	2,896	208	1,070	56	73,423
12	56,632	193	16,411	2,891	291	1,197	94	71,090
13	56,272	193	16,588	2,892	320	1,096	76	69,434
14	56,695	193	16,705	2,882	317	1,092	76	69,261
15	58,188	193	16,819	2,822	326	1,166	86	69,594
16	60,083	193	16,908	2,798	292	853	83	71,379
17	60,558	193	17,637	2,791	333	951	92	73,070
18	59,230	193	18,292	2,797	336	1,468	164	73,620
19	56,271	193	18,828	2,797	341	2,295	86	71,930
20	52,410	193	19,091	2,793	339	2,396	76	69,365
21	49,841	193	19,236	2,795	343	3,402	76	64,794
22	48,835	193	19,414	2,791	354	2,994	172	62,841
23	47,790	193	19,805	2,795	360	3,593	34	61,314
24	46,378	193	20,112	2,777	356	3,195	223	61,525
25	44,862	194	20,225	2,871	370	4,090	108	59,478
26	42,208	195	20,198	3,727	327	5,393	191	56,075
27	40,719	196	19,848	4,269	377	4,500	194	53,771
28	40,307	196	19,576	4,278	256	4,299	58	52,490
29	39,798	197	19,308	4,305	162	4,351	0	51,772
30	38,968	198	19,070	4,403	165	4,110	232	51,359
AVERAGE	55,667	194	18,024	2,862	293	2,189	92	73,732

Appendix F. Delta outflow (in cfs): December 1997 -- July 1998.

July 1998

Date	Sacramento River At Freeport	Sacramento Treatment Plant	San Joaquin River Near Vernalis	Tracy Pump	Contra Costa Pump	Clifton Court Forebay Inflow	Byron-Bethany Irrigation District	Delta Outflow Index
1	37,462	199	18,730	3,910	156	3,767	68	51,004
2	34,133	199	17,652	3,753	186	4,397	93	48,666
3	34,571	199	16,584	3,794	168	3,996	121	44,588
4	33,596	199	15,849	3,675	169	3,497	0	44,367
5	32,605	199	15,469	3,681	243	3,300	71	42,727
6	32,128	199	15,541	3,682	362	3,500	71	41,007
7	31,420	199	15,890	3,682	380	2,034	74	42,035
8	29,656	199	15,873	3,679	367	148	100	43,594
9	29,283	199	16,119	3,529	371	995	148	41,092
10	28,759	199	16,240	3,993	362	3,397	173	38,061
11	27,997	199	17,259	4,312	343	3,390	173	37,294
12	26,922	199	18,311	4,313	374	2,995	50	37,513
13	25,979	199	18,821	4,295	371	0	130	40,486
14	25,607	199	18,373	4,295	383	796	129	39,234
15	25,031	199	17,044	4,295	384	4,999	124	34,249
16	24,280	199	16,145	4,261	409	4,993	93	32,010
17	23,880	199	15,683	4,254	413	5,123	116	30,041
18	23,236	199	14,362	3,666	414	4,367	106	30,514
19	23,077	199	13,279	3,421	412	4,677	101	28,480
20	22,972	199	12,496	3,415	412	4,490	92	27,485
21	22,338	199	12,227	3,939	403	4,800	108	25,772
22	22,837	199	11,628	4,328	377	3,592	107	25,727
23	22,816	199	11,353	4,339	408	3,596	101	25,581
24	22,644	199	11,097	4,326	401	3,979	97	24,942
25	23,053		10,491	4,327	398	4,000	54	24,464
26	23,426		9,664	4,268	395	6,498	101	21,849
27	23,708		9,575	4,379	368	3,992	140	23,655
28	23,521		8,254	4,486	390	3,999	130	23,731
29	23,569		8,150	4,502	403	3,820	130	22,489
30	23,000		7,599	4,524	386	3,800	148	22,493
31				4,522	359	3,883	138	21,294
AVERAGE	26,784	199	14,192	4,060	354	3,575	106	33,434